True*Grid*® User's Manual

A Guide and a Reference

by

Robert Rainsberger

VOLUME 1:

Introduction, Graphical User Interface, and Parts

Version 4.0.0

XYZ Scientific Applications, Inc.

August 13, 2019

Copyright © 2018 by XYZ Scientific Applications, Inc. All rights reserved.

True*Grid*,® the **True*Grid***® User's Manual, and related products of XYZ Scientific Applications, Inc. are copyrighted and distributed under license agreements. Under copyright laws, they may not be copied in whole or in part without prior written approval from XYZ Scientific Applications, Inc. The license agreements further restrict use and redistribution.

XYZ Scientific Applications, Inc. makes no warranty regarding its products or their use, and reserves the right to change its products without notice. This manual is for informational purposes only, and does not represent a commitment by XYZ Scientific Applications, Inc. XYZ Scientific Applications, Inc. accepts no responsibility or liability for any errors or inaccuracies in this document or any of its products.

True*Grid* ® is a registered trademark of XYZ Scientific Applications Inc..

OpenGL, **Silicon Graphics**, and **SGI** are registered trademarks of Silicon Graphics International Corp.
WINDOWS is a registered trademarks of Microsoft Corporation.
UNIX is a registered trademark of The Open Group.
ABAQUS® is a registered trademark of Abaqus, Inc.
SUN and **SUN MICROSYSTEMS** are registered trademarks of Sun Microsystems, Inc.
ANSYS, **TASCFlow**, **AUTODyn**, **FLUENT**, and **CFX** are registered trademarks or trademarks of ANSYS, Inc.
PATRAN is a trademark and a registered trademark, respectively of MacNeal Schwendler Corporation
FIDAP are registered trademarks of Fluent, Inc.
CFD-ACE is a trademark of CFD Research Corporation
GRIDGEN is a trademark of Pointwise, Inc.
NASTRAN is a registered trademark of The National Aeronautics Space Administration
LSDYNA is a trademark of Livermore Software Technology Corporation
STAR-CD is a trademark of CD Adapco Group
SAP2000 is a registered trademark of Computers and Structures, Inc.
MPACT is a trademark of MPACT Corp.
LINUX is a registered trademark of Linus Torvalds
HP is a trademark of Hewlett-Packard Company
IBM is a registered trademark of the IBM Corporation
SUSE is a trademark of Novell, Inc.
INTEL is a registered trademark of the Intel Corporation
AMD is a trademark of Advanced Micro Devices, Inc.

Some other product names appearing in this book may also be trademarks or registered trademarks of their trademark holders.

Preface

New Features

Since the publishing of this manual for version 3.0 in 2014, there have been numerous new releases of **True*Grid*®** plus this major release. Below is a list highlighting the most significant improvements to **True*Grid*®** since that publication.

•

- **TRUE*GRID*®** EXECUTION
  - The precision and graphics description has been added to the version and date information when **True*Grid*®** is run.
  - There is a new **True*Grid*®** License Manager and it is required with this new version of **True*Grid*®** . This new **True*Grid*®** License Manager and new **True*Grid*®** are incompatible with the previous **True*Grid*®** License Manager and previous **True*Grid*®**.

- FORMATTED OUTPUT
  - Triquadratic 27 node brick and 9 node shell elements are available and valid for the output options **NEK5000**, **LSDYNA**, **ABAQUS**, **MPACT**, and (a modified) **NASTRAN**.
  - The **NERL** command now works with the **QUADRATIC** and **TRIQUADRATIC** commands.
  - The number of different cards generated for **NASTRAN** has been greatly increased and are too numerous to list here. There is a new **True*Grid*®** to NASTRAN manual with all of the details.
  - There is a new output format for **NEK5000** using **QUADRATIC** or **TRIQUADRATIC**. These element types can also be used with **LSDYNA**, **ABAQUS**, **MPACT**, and modified **NASTRAN**.
  - The new command **NEKOPTS** is used to set **NEK5000** analysis switches and parameters. The new command **NEKTOL** sets the tolerance used to decide if an edge of the **NEK5000** mesh is non-linear. The new **GEOP**/**GEOPI** commands specifies the boundary curvature.
  - The **LSDYNA** output can be up to 99,999,999 nodes.
  - Pressure (**PR**), convection (**CVT**), and traction (**TRACT**) loads are now available for **ABAQUS**, **ANSYS**, and **NASTRAN** with both linear and quadratic elements.
  - The **ABAQUS** step command, **ABAQSTEP**, now includes traction. The pressure (**PR**), boundary constraints (**B**), force (**FC**), moments (**MOM**), fixed displacement (**FD**), acceleration (**ACC**), and traction (**TRACT**) have a load curve/set ID parameter so that these properties can also be applied using the **ABAQUS** STEP (**ABAQSTEP**) feature. Additionally, the multiple point constraint (**MPC**), boundary constraint in a local coordinate system (**LB**/**LBI**), and temperature (**TE**/**TEI**) commands now have load curve/set id used by **NASTRAN** to associate properties with processes.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

• Local coordinate systems written to **LSDYNA** has been minimized.
• The **LSDYNA** material 72 has been replaced with 72REL3.
• Verbatim data for **LSDYNA** now comes after the material data.
• The LLNL DYNA3D (**DYNAMATS**) material 24 has been updated.
•The **ABAQSTEP** command has a new option, **ABDLOAD**, to select distributed loads in a step. Distributed loads can be generated using the new **DSLOAD** command.
• The **NSETC**, **ESETC**, and **FSETC** commands can be used to set the title for node sets, element sets, and segment sets for **LSDYNA**. The **VFL** and **VFLI** commands now generate variable flux for **LSDYNA**.
• Use the **QUADRATIC** command before generating the mesh to get 20 node hexa elements for **LSDYNA**. Use the **TRIQUADRATIC** command to get 27 node hexa elements for LSDYNA.
• The \{ and \} character pairs produce { and } respectively in a verbatim/endverbatim command.
• The command **SHOFF** offsets the reference surface of a shell for **LSDYNA** and **NASTRAN**.
• The new **MPCE** (multiple point constraint equation) can be used for **ABAQUS**, **ANSYS**, **LSDYNA**, **NEUTRAL**, and **NASTRAN** output.
• The **BSD** command has been extended to support quadratic beam cross section properties for **NASTRAN**.
• The new discrete element method **DEMICLE** and **DEMP**/**DEMPI** commands generate discrete elements and the properties for **LSDYNA**.
• The session file, usually called tsave, now has a header identifying the user, date, and system used.

●PARAMETRIC FEATURES

• Automatic parameters are set when the **MEASURE** command is used to measure the quality of the mesh.
• Memory for the macro control statements **FOR**/**ENDFOR**, **WHILE**/**ENDWHILE**, and **WHEN**/**ELSEWHEN**/**ELSE**/**ENDWHEN** have been extended
• A pair of new merge phase commands, **AJEL** and **SAJEL**, locates the element that is closest to a point. The element number is assigned to the automatic parameter %ELEMENT.
• The new command **APAINFO** lists all of the automatic parameters, their meaning, and their value.
• Automatic parameters can retrieve knot and control points from the last defined cubic, B, or NURB spline 3D curve.
• A new option in the **SPLINE**, **LP3**, or **TWSURF** point list dialogue retrieves all the parameters that formed a previously generated 3D curve by its 3D curve identification number.
• Automatic parameters contain the intersections of two 2D curves using the **IPIL** option of the **LD** command. Alternatively, use the new **IT2DC** command.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

●IMPORTING A MESH

• The **READMESH** LSDYNA now includes reading SET_NODE, _SEGMENT, _BEAM, _SHELL, _SOLID, and _TSHELL and associated data in the **True*Grid*®** data base.
• The **READMESH** for NASTRAN files now imports data from the following cards: CHEXA, CTRETRA, CPENTA, CPTRAM, CPYRAM, CHEXA27, CQUAD4, CQUADR, CQUAD8 CTRIA4, CTRIAR, CTRIA8, CTRIA6, CTRIA3, CTRIAR, CBEAM, CBEND, CROD, CTUBE, CBAR, CELAS1, CELAS2, CSHEAR, FORCE, FORCE1, FORCE2, GRID, GRDSET, CORD, MAT1, MAT2, MAT4, MAT5, MAT8, MAT9, MAT10, MATT9, MOMENT, MOMENT1, MOMENT2, PLOAD, PSHEAR, PELAS, RBE2, PBEAM, PBAR, PTUBE, PROD, PBCOMP, PBEND, PCOMP, PSHELL, and PSOLID.

●GRAPHICS

• 3D curves and points can be labeled in fill graphics.
• The **CO THIC** command to show variable thickness shells now works in the FILL graphics mode.
• The **CO THIC** command applies to 3, 4, 6, 7, 8, and 9 node shell elements.
• The command **LABELS PARTS** highlights parts in wire, hide, and fill graphics mode in both the part and merge phase.
• The **SET THICK** command sets the line thickness in postscript files as well as the wire and hide graphics in both the part and merge phase.
• **SPH** elements are now available in fast graphics.
• **SET** options in the part phase now match those in the merge phase.
• The **CO** command has a new option, **DEM**, to display discrete elements.

●TRANSFORMATIONS

• **TRPRT** is a new command in the merge phase which can transform a part.

●DIAGNOSTICS

• The command to change the Guassian quadrature for the **MEASURE** command (**VIGQ**) can now be set as high as 5.
• The **MEASURE** and **MEA**/**MEAI** commands have been improved so that the shape functions for penta and tetra elements are used instead of being treated as a degenerate hexa.
• If a merge command is issued in the part phase, then the **MEASURE** command in the part phase (**MEA**/**MEAI**) will merge the nodes of a element before it is measured so that the proper shape function is used.
• There are 4 new global element quality measures in the **MEASURE** command during the merge phase.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

●GEOMETRY

• The Hermite surface memory usage has been greatly improved.
• The new commands **GEOP** and **GEOPI** identify edges of a **NEK5000** mesh with special curvature.
• Trimmed and composite surface (IGES geometry) can be used to form mid-plane surfaces, which in turn can be used to define variable thickness shells. The mid-plane surface accuracy has been increased.
• A new command, **SP4PT**, finds the center and radius of a sphere from 4 points that are not co-linear nor co-planar
• The new command **STL** output command writes a Stereo Lithography file in either ASCII or BINARY format.

●MESH

• The **TRIQUADRATIC** command causes 27 node hexa elements to be generated and 9 node quad shell elements to be generated.
• The **ALLTETS** command can be used in the merge phase to convert a hexa mesh to a treta mesh.
• Face sets formed in the part phase now include faces from transition elements, including faces from quadratic and triquadratic elements.
• The local verses global coordinate system selected in the Environment window under the Pick option now applies to both the DISPLAY LIST panel and the LABELS PANEL of the Environment window.
• The **MTV** command now includes shells.
• The **MTV** command option 3 has been extended to non-convex surfaces.
• The **SSF** and **SSFI** commands have been extended to include 8 and 9 node shell elements. All variable thickness shell elements that with a common node will have the same thickness at that node.
• An integer can be used to name a set.
• Face ID numbers for penta and tetra elements are now assigned using a method that is different from the way hexa element faces are identified. This is a more consistent way of forming face sets from penta and tetra elements.
• One and two way transitions (see **TRBB** command) now include **TRIQUADRATIC** elements.

●LOADS AND BOUNDARY CONDITIONS

• The new merge phase **TRACT** command assigns traction.
• Properties on faces such as inlets, outlets, periodic conditions can now be viewed using the condition (**CO**) command in the merge phase.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

• The new command, **DSLOAD**, in the merge phase was added to specify distributed surface loads in an ABAQUS model.
• The **PR**/**PRI**, **CVT**/**CVTI** (ANSYS only), in the part phase and the **PR**, **CVT** (ANSYS only), and **TRACT** commands in the merge phase for the **ABAQUS**, **ANSYS**, and **NASTRAN** output options now includes quadratic elements.
• The new **MPCINFO** command lists all of the **MPC** node sets.
• The **SFB** command to automatically generate nodal constraints within local coordinate systems normal to a surface has been extended to apply to edges and vertices.
• The new **MPCE** command creates multiple point constraint equations for **ANSYS**, **ABAQUS**, **NASTRAN**, **NEUTRAL**, and **LSDYNA** output.
• The **CO** command has a new option to display the **MPCE**s. This works for wire, hide, fill, and Fast Graphics.

Documentation

The following **True*Grid*®** documents are available:

True*Grid*® User's Manual Volumes 1 and 2- These are the most important documents which contain instructions on the use of **True*Grid*®** and a reference for the functionality of each command. They are available in PDF format and hard copy.

True*Grid*® Examples Manual - This manual has numerous examples from the most basic using only one or two commands to full models. There are also sections of command input extracted from larger models to be instructive on certain topics. Several full models with annotations are included. All examples have color graphics. This is available in PDF format and hard copy.

True*Grid*® Tutorial - The documentation is intended to aid a beginning **True*Grid*®** user in self paced training course. It only teaches enough of **True*Grid*®** to build simple meshes. Approximately 6 to 10 hours are needed to work through this course. This is available in PDF format and in hard copy.

Introductory **True*Grid*®** Training Manual - This is a set of view graphs used in the introductory training for **True*Grid*®** usually held once a month at the main office for XYZ Scientific Applications, Inc. This course can be made available at your facility. The view graphs are available in PDF format.

Advanced **True*Grid*®** Training Manual - This is a set of view graphs and examples used in the advanced **True*Grid*®** training course held occasionally at the main office for XYZ Scientific Applications, Inc. This course can be made available at your facility. The view graphs are available in PDF format. A CD is available with the examples.

True*Grid*® Output Manuals - These manuals have all of the commands and options to define the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

material models, analysis options, element types, constraints and conditions specific to each output format supported by **True*Grid*®**. This includes the formatted output for ABAQUS, ANSYS, AUTODYN, DYNA3D, FLUENT, KIVA, LSDYNA, MPACT, NASTRAN, NEK5000, NIKE3D, and STARCD.

True*Grid*® License Manager Manual - This manual describes the operations of the license manager used by **True*Grid*®**. It is intended for system administrators. It is available in PDF format.

RELEASENOTES* - Every minor release of **True*Grid*®** does not warrant a new version of the manuals. Instead, the improvements are listed in these files which accompany the new version of **True*Grid*®**. This is available in text and PDF format.

Install_WIN - These are the installation instructions for **True*Grid*®** for WINDOWS operating systems. It is available in text and PDF format.

Install_LINUX - These are the installation instructions for **True*Grid*®** for REDHAT LINUX operating systems. It is available in text and PDF format.

License - The varies licensing agreements for **True*Grid*®** are available in text and PDF format. The CD is always shipped with a hard copy of the appropriate agreement. This agreement requires that you agree to honor XYZ Scientific Applications' copyright ownership and authorization of **True*Grid*®** in order to use **True*Grid*®**.

Updates

If you are licensed to run the latest version of **True*Grid*®**, you can get the latest updates and documentation on a CD from XYZ Scientific Applications, Inc. or its distributors. These updates are also available on the web for down loading. Please contact XYZ Scientific Applications, Inc. At (925) 349-6318 for instructions on down loading from the web.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Table of Contents

Table of Contents 9

I. Introduction 21
1. What is True*Grid*® ? 22
2. Availability. 24
Getting Information on True*Grid*® 24
Getting a Demonstration Copy of True*Grid*® 24
Purchasing A True*Grid*® License 25
3. Installation and Licensing 25
Learning True*Grid*® 26
Using the Manual 27
Getting Help 28
4. True*Grid*® Basic Concepts 29
Two Kinds of Mesh 29
Making Parts and Merging them into a Model 30
Regions, Indices, and Reduced Indices 32
5. How True*Grid*® Works 36
Topology Of The Mesh 36
Full Indices 36
Shape Of The Mesh 36
Part Initialization 37
Projection Method 38
Advantages of the Projection Method 38
Surface Intersection Method 39
Command Hierarchy 40
Multiple Block Structured Parts 40
Quality Meshes 42
Algebraic Methods 42
Interactivity 42
Specifying Multiple Blocks 43
Initial Coordinates 43
Cylindrical Coordinate Systems 44
Mesh Density Parameterization 44
Reduced Indices 45
Vertices and Regions 45
Index Progressions 47
Graphical Version of Index Progressions 49
Examples 50
6. Conventions 55

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

7. Running True*Grid*®. 55
Execution Environment. 56
Two Modes and Two Input Channels. 56
Command Line. 57
Mesh Generation. 62
Termination. 62
CAD/IGES Geometry. 62
File and Path Names With Spaces. 63
Miscellaneous. 63
Phases. 64
Basic Interactive Session. 65

II. Graphical User Interface. 69
1. TrueGrid Windows. 70
2. The Text/Menu Window. 72
Menu Window. 72
Text Window. 74
3. Graphics Commands. 75
ad define a numbered annotation. 75
aad add an annotation to the picture in the physical window. 75
caption change or toggle caption. 75
daad display all annotations in the physical picture. 76
dad display a single annotation in the physical picture. 76
dads display a list of annotations in the physical picture. 77
display display with general hidden-line algorithm. 77
draw display without hidden line. 77
grid turn reference grid on or off. 78
pad position an annotation in the physical picture. 78
poor poor man's hidden line removal. 79
postscript activate PostScript output. 79
raad remove all annotations from the physical picture. 80
rad remove an annotation from the physical picture. 80
rindex label reduced indices. 81
sdint toggle display of surface interior. 81
set define various graphic options. 81
slice slice through the picture. 83
triad turn triad on or off. 84
tvv color and shaded display. 85
zclip remove front portion from physical picture. 85
4. Picture Controls. 86
l move picture left. 87
r move picture right. 87

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

u move picture up. . . . 88
d move picture down. . . . 88
rx rotate about the x axis. . . . 88
ry rotate about the y axis. . . . 89
rz rotate about the z axis. . . . 89
trans translate to new center of rotation. . . . 89
fix freeze center of rotation. . . . 90
unfix return center of rotation to picture. . . . 90
scale scale all coordinates. . . . 90
xscl scale x-coordinate. . . . 90
yscl scale y-coordinate. . . . 91
zscl scale z-coordinate. . . . 91
zb zoom back. . . . 91
zf zoom forward. . . . 92
angle perspective angle. . . . 92
reso change display resolution. . . . 92
restore return to original or fixed view. . . . 93
center fit picture to the screen. . . . 93
5. Computational Window. . . . 94
Selecting Regions and Index Progressions with the Index Bars. . . . 95
Selecting a Region with Click-and-Drag in the Computational Window. . . . 102
Index Bar Zone. . . . 104
6. The Environment Window. . . . 105
Choosing the Type of Picture. . . . 105
Selecting the Windows to be Redrawn. . . . 108
phys turn the Phys button on. . . . 108
both turn the Both button on. . . . 108
comp turn on the Comp button. . . . 108
Generating a New Picture. . . . 108
Dynamically Moving the Picture. . . . 109
Labels Panel - Labeling Objects 111
Pick Panel - Pick an Object. . . . 120
Coordinate System of a Picked Point. . . . 121
Pick Panel - Picking a Point by Projection. . . . 122
Pick Panel - Pick a Point by Z-buffer. . . . 122
Pick Panel - Picking a Node. . . . 123
Pick Panel - Picking a Vertex. . . . 123
Pick Panel - Picking Partial Coordinates. . . . 125
Pick Panel - Picking an Edge, Face, or Block. . . . 125
Pick Panel - Creating or Modifying Sets Using the Mouse. . . . 129
Display List Panel - Determining What Objects are Drawn. . . . 137
Move Pts. Panel - Interactively Moving Regions of the Mesh. . . . 143

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Deleting a Region of the Mesh. . . . 151
Attaching the Mesh to Objects. . . . 152
Projecting a Mesh Region to a Surface. . . . 160
The Undo Feature. . . . 166
The History Button. . . . 166
The Resume Command. . . . 166
7. Dialogue Boxes. . . . 167
Option Lists. . . . 168
Numbers, Lists of Numbers, and Text Strings. . . . 169
Parser and Fortran Interpreter. . . . 170
Editing and Syntax Checking. . . . 171
Executing and Quitting Dialogue Boxes. . . . 171
Quick Reference to Keyboard Functions. . . . 172
8. Interactive Construction of 3D Curves. . . . 173

III. Part Commands. . . . 192
1. Geometry and Topology. . . . 193
de delete a region of the part. . . . 195
dei delete regions of the part. . . . 195
insprt insert a partition into the existing part. . . . 195
lmseq change the number of elements in a block. . . . 199
mseq change the number of elements in the part. . . . 199
orpt set shell element normal orientation. . . . 200
update save the mesh's present state as the initial mesh. . . . 202
2. Initial Positioning of Vertices. . . . 203
mb translates vertices. . . . 204
mbi translates vertices. . . . 205
pb assigns coordinates to vertices. . . . 206
pbs assign coordinates to vertices from a labeled point. . . . 207
cooref selects feature in the pbs command. . . . 208
tr transform a region of the mesh. . . . 208
tri transform regions of the mesh. . . . 210
ilin initial interpolation - not a constraint. . . . 211
ilini initial interpolation - not a constraint. . . . 212
ma translates vertex before interpolations or projections. . . . 212
pa assigns coordinate values to a vertex 213
q assigns coordinates of one vertex to another. . . . 214
3. Initial Positioning of Edges. . . . 214
cur distribute edge nodes along a 3D curve. . . . 224
curf distribute and freeze nodes along a 3D curve. . . . 225
cure distribute nodes along an entire 3D curve. . . . 225
curs independently distribute edge nodes along a 3D curve. . . . 226

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

edge distribute nodes along an edge of a surface. 227
4. Interpolation. 230
esm 2D elliptic smoothing. 231
esmp Add source terms for elliptic smoothing. 234
hyr Interpolate multiple regions as one region. 235
lin Linear interpolation. 235
lini Linear interpolation by index progression. 243
relax Equipotential relaxation. 243
relaxi Equipotential relaxation. 246
splint Interpolate edges along cubic splines. 246
tf Transfinite interpolation. 247
tfi Transfinite interpolation, by index progression. 252
tme Thomas-Middlecoff relaxation. 252
tmei Thomas-Middlecoff relaxation, by index progression. 257
neu Orthogonal boundary smoothing. 257
neui Orthogonal boundary smoothing, by index progression. 261
unifm Uniform smoothing. 261
unifmi Uniform smoothing. 265
5. Projection. 265
sf project a region onto a surface. 266
sfi project regions onto a surface by index progression. 269
spp spherical projection. 270
tmplt create template used by spp. 272
patch attaches a face to a 4 sided surface patch. 272
ms sequence of surface projections. 273
6. Nodal Spacing Along Edges. 275
res relative spacing of nodes of an edge. 275
drs relative spacing of nodes of an edge from both ends. 277
as absolute spacing of first or last element of an edge. 278
das absolute spacing of first and last element of an edge. 278
nds generalized nodal distributed along an edge. 279
ndd nodal density distribution function. 279
dndd display a numbered density distribution function. 281
7. Equations. 282
dom specify the region applied to x=, y=, z=, t1=, t2=, and t3=. 283
x= assign x-coordinates by evaluating a function. 283
y= assign y-coordinates by evaluating a function. 286
z= assign z-coordinates by evaluating a function. 286
t1= assign a temporary mesh variable by evaluating a function. 286
t2= assign a temporary mesh variable by evaluating a function. 287
t3= assign a temporary mesh variable by evaluating a function. 287
8. Edit Commands. 287

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

history show the history table. . . . 288
actcmd activate a mesh command previously deactivated. 292
decmd deactivate a mesh command. . . . 292
undo deactivate the last active mesh command. . . . 293
9. Select Regions For Display. . . . 293
arg add a region to the display. . . . 294
argi add a progression to the display. . . . 295
darg display all regions. . . . 296
darged display all edges. . . . 297
rg display a region. . . . 298
rgi display a progression. . . . 298
rrg remove a region from display. . . . 298
rrgi remove a progression from display. . . . 299
strghl highlight region. . . . 299
strghli highlight index progression. . . . 299
clrghl clear highlighted selection. . . . 300
10. Labels in the Picture. . . . 300
labels specify type of label to be displayed. . . . 300
11. Displacements, Velocities, and Accelerations. . . . 300
fd fixed displacement. . . . 301
fdi fixed displacement by index progression. . . . 301
fdc cylindrical fixed displacement. . . . 302
fdci cylindrical fixed displacement. . . . 303
fds spherical fixed displacement. . . . 304
fdsi spherical fixed displacement. . . . 304
frb prescribed nodal rotation. . . . 306
frbi prescribed nodal rotation by index progression. . . . 306
fv prescribed velocities. . . . 307
fvi prescribed velocities. . . . 308
fvc cylindrical prescribed velocities. . . . 309
fvci cylindrical prescribed velocities. . . . 309
fvs spherical prescribed velocities. . . . 310
fvsi spherical prescribed velocities by index progression. . . . 310
bv prescribed boundary surface velocities for NEKTON. . . . 311
bvi prescribed boundary surface velocities for NEKTON. . . . 311
acc prescribed boundary acceleration. . . . 311
acci prescribed boundary acceleration. . . . 312
accc cylindrical prescribed boundary acceleration. . . . 313
accci cylindrical prescribed boundary acceleration. . . . 313
accs spherical prescribed boundary acceleration. . . . 315
accsi spherical prescribed boundary acceleration. . . . 315
dis initial displacement in a region. . . . 316

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

disi initial displacement by index progression. 317
fvv variable prescribed nodal boundary velocities. 317
fvvi variable prescribed nodal boundary velocities. 318
fvvc cylindrical variable nodal prescribed boundary velocities. 319
fvvci cylindrical variable prescribed nodal boundary velocities. 320
fvvs spherical variable prescribed nodal boundary velocities. 321
fvvsi spherical variable prescribed nodal boundary velocities. 321
vacc variable prescribed nodal boundary accelerations. 321
vacci variable prescribed nodal boundary accelerations. 322
vaccc cylindrical variable nodal prescribed boundary accelerations. . . 322
vaccci cylindrical variable prescribed nodal boundary accelerations. . . 323
vaccs spherical variable prescribed nodal boundary accelerations. 324
vaccsi prescribed nodal boundary accelerations (spherical). . . . 324
rotation part initial rigid body rotation. 324
velocity part initial velocity. 325
ve initial velocity in a region. 325
vei initial velocity by index progression. 325
12. Force, Pressure, and Loads. 326
arri modify pressure amplitudes and shock arrival time. 326
dist laser distribution function. 331
csf cross section forces for DYNA3D. 332
fa fixed nodal rotations. 332
fai fixed nodal rotations. 333
fc concentrated nodal loads. 333
fci concentrated nodal loads. 334
fcc cylindrical concentrated nodal loads. 334
fcci cylindrical concentrated nodal loads. 335
fcs spherical concentrated nodal loads. 336
fcsi spherical concentrated nodal loads. 336
ll linearly interpolate loads by arc length. 337
mdep momentum deposition. 338
mom nodal moment about an axis. 339
momi nodal moment about an axis. 340
ndl nodal distributed load. 340
ndli nodal distributed load. 341
pr pressure load. 342
pri pressure load by index progression. 343
pramp pressure amplitudes from a FORTRAN like expression. 344
13. Boundary and Constraint Commands. 345
b global nodal displacement and rotation constraints. 346
bi global nodal constraints, by progression. 347
cfc convective flow (CF3D) output boundary conditions. 348

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

cfci CF3D output boundary conditions by progression. 349
fbc FLUENT boundary conditions. 349
fbci FLUENT boundary conditions by index progression. . . . 350
jt assign a node to a numbered joint. 351
il identifies an inlet for fluid flow... 353
ili identifies an inlet for fluid flow, by index progression. 353
kiva3bc set boundary conditions for KIVA3v. 353
kiva3bci set boundary conditions for KIVA3v. 354
kivabc boundary conditions for kiva4 output format. 355
kivabci boundary conditions for kiva4 output format. 356
lb local nodal displacement and rotation constraints. 356
lbi local nodal boundary constraints, by progression. 357
namreg name a region for the TASCFLOW output file. 358
namregi name regions for the TASCFLOW output file. 358
nr non-reflecting boundary. 358
nri non-reflecting boundaries. 358
ol face outlet for fluid flow. 358
oli identifies faces of the mesh as an outlet for fluid flow. 359
reg select a region for the REFLEQS boundary condition. 359
regi select regions for the REFLEQS boundary condition. 360
sfb locally constrain face nodes. 360
sfbi locally constrain face nodes by progression. 362
sw assign nodes that may impact a stone wall. 363
swi assign nodes that may impact a stone wall. 363
syf assign faces to a numbered symmetry plane with failure. 364
syfi assign faces to a numbered symmetry plane with failure. 364
trp create tracer particles for Lsdyna. 364
14. Radiation and Temperature Commands. 365
bf bulk fluid. 365
bfi bulk fluid by index progression. 365
cv boundary convection. 366
cvi boundary convection. 366
vcv boundary convection with functional amplitudes. 366
vcvi boundary convection with functional amplitudes. 367
cvt convection thermal loads. 367
cvti convection thermal loads. 368
fl prescribed boundary flux. 368
fli prescribed boundary flux. 368
vfl prescribed boundary flux with functional amplitude. 369
vfli prescribed boundary flux with functional amplitude. 369
ft prescribed temperature. 369
fti prescribed temperature by progression. 370

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

vft functional prescribed temperature. 370
vfti functional prescribed temperature by progression. 370
hfl specify flows and fluxes. 371
hfli specify flows and fluxes, by index progression. 371
inizone initial conditions for the REFLEQS option. 371
inizonei initial conditions for the REFLEQS option. 372
setsor set REFLEQS source terms. 373
setsori set REFLEQS source terms, by index progression. 373
rb prescribed radiation boundary condition. 374
rbi prescribed radiation boundary condition, by progression. 374
vrb prescribed radiation boundary w/ functional amplitudes. 375
vrbi prescribed radiation boundary, by progression w/ functional amplitudes. 375
re radiation enclosure. 376
rei radiation enclosure by index progression. 376
te constant nodal temperature. 377
tei constant nodal temperature. 377
temp part default constant nodal temperature 377
tepro variable nodal temperature profile. 377
tm initial temperature condition. 378
tmi initial temperature condition by index progression. 378
vtm initial temperature w/ functional temp. 378
vtmi initial temperature by index progression w/ functional temp. . . . 378
vhg volumetric heat generation. 379
vhgi volumetric heat generation by index progression. 379
vvhg volumetric heat generation w/ functional amplitude. 379
15. Electric Condition Commands. 379
efl electric flux boundary condition. 379
efli electric flux boundary condition by index progression. 380
mp constant magnetic potential. 380
mpi constant magnetic potential. 380
v electrostatic potential boundary condition. 380
vi electrostatic potential boundary condition. 380
16. Springs, Dampers, and Point Masses. 381
npm creates a node with a point mass. 381
pm point mass to a vertex of the present part. 382
spdp assigns a face to be half of a set of spring/damper pairs. 382
spring create/modify a spring. 383
17. Interfaces and Sliding Surfaces. 385
bb block boundary interface. 385
bbinfo block boundary interface information. 391
dbb display a block boundary in the picture. 392

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rbb remove a block boundary from the picture. 393
abb add a block boundary to the picture. 393
dbbs display a set of block boundaries in the picture. 393
rbbs remove a set of block boundaries from the picture. 393
abbs add a set of block boundaries to the picture. 393
dabb display all block boundaries.. 393
rabb remove all block boundaries from the picture. 394
bbint block boundary interior mesh lines.. 394
chz cohesive shell elements. 394
chzi cohesive shell elements. 395
flowint create named regions for the CFX output file. 395
flowinti create named regions for the CFX output file. 396
iss save interface segments. 397
issi save interface segments. 397
si assign sliding interface to region. 397
sii assign sliding interfaces. 398
trbb slave transition block boundary interface. 401
shtoso shell to solid interface by region. 408
shtosoi shell to solid interface by progression. 409
18. Automatic Rivet Hole generation. 410
19. Special Element Generation and Properties. 418
demp discrete element spheres' properties by regions.. 418
dempi discrete element spheres' properties by progression. 419
esh create a shell mesh attached to a solid mesh.. 419
eshi create a shell mesh attached to a solid mesh.. 419
geop geometry properties for NEK5000. 420
geopi geometry properties for NEK5000. 420
nektol tolerance used by geop/geopi for NEK5000.. 421
n set orientation of normals on shells. 421
or orientation of element local coordinate axes. 422
shoff offset shell reference surface. 422
shoffi offset shell reference surface. 423
ssf project shell onto an interpolated surface. 423
ssfi project shell onto an interpolated surface, by progression. 424
th thickness of shell. 424
thi thickness of shell. 424
thic default shell thickness 425
20. Beams. 425
ibm generate beams in the i-direction. 425
ibmi generate beams in the i-direction by index progression. 429
jbm generate beams in the j-direction. 432
jbmi generate beams in the j-direction by index progression. 434

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

kbm generate beams in the k-direction. . . . 437
kbmi generate beams in the k-direction by index progression. . . . 440
21. Diagnostics Commands. . . . 445
mea choose a way to measure mesh quality. . . . 445
meai choose a way to measure mesh quality. . . . 447
vigq quadrature rule for mass calculations. . . . 448
22. Parts Commands. . . . 448
cycorsy frame of reference for cylinder part. . . . 448
endpart complete the part and add it to the data base. . . . 449
savepart save all part data in a parts data base. . . . 450
23. Replication of Parts. . . . 450
lrep local replication of a part. . . . 451
grep global replication of a part. . . . 454
24. Merging of Parts. . . . 456
fn tied node sets with failure. . . . 458
fni tied node sets with failure. . . . 460
25. Output Commands. . . . 461
epb element print block. . . . 461
npb nodal print block. . . . 461
supblk select regions to be combined in the block structured output 461
26. Sets. . . . 462
delset delete a set. . . . 463
eset add/remove elements to/from a set of elements. . . . 463
eseti add/remove elements to/from a set of elements. . . . 464
fset add/remove faces to/from a set of faces. . . . 465
fseti add/remove faces to/from a set of faces. . . . 466
nset add/remove nodes to/from a set of nodes. . . . 467
nseti add/remove nodes to/from a set of nodes. . . . 468
nsetc attach a comment to a node se. . . . 469
fsetc face set comment. . . . 470
esetc element set comment. . . . 470
nsetinfo report the node set names and number of nodes. . . . 470
27. Material Commands. . . . 470
mate part default material number for each region 471
mt material number for a region. . . . 471
mti assign material number. . . . 471
mtv material number assigned to a specified volume. . . . 476
por to specify the region with porosity for REFLEQS. . . . 480
pori to specify the region with porosity for REFLEQS. . . . 480
sc to define the ale smoothing constraints for LS-DYNA3D. . . . 480

IV. Index. . . . 482

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

I. Introduction

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

1. What is True*Grid*® ?

True*Grid*® is a powerful, interactive and batch, mesh generator. It can create meshes of unsurpassed quality more quickly and easily than by any other method. With this tool, you can generate meshes for finite difference and finite element simulation codes that model the behavior of fluids and structures. However, it is more than a mesh generator – it can generate complete input files for many simulation codes.

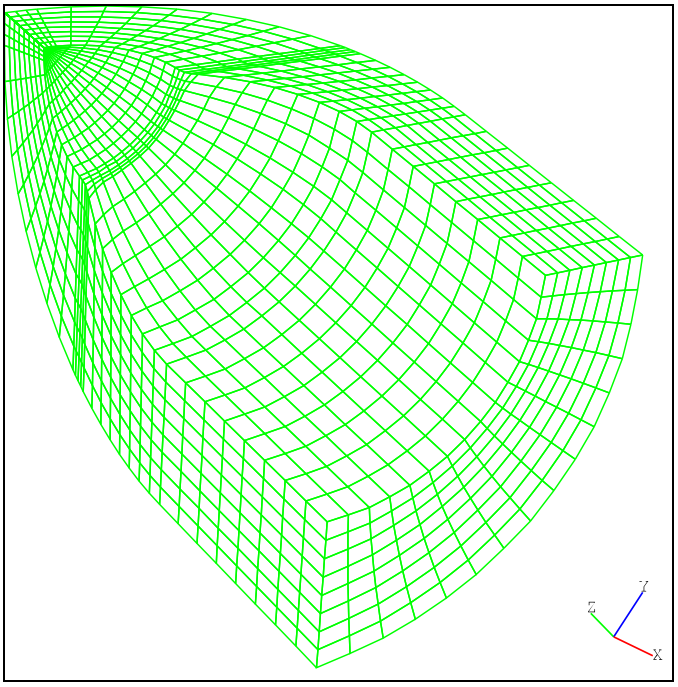


Figure 1 Mesh about rocket section

True*Grid*® is fundamentally a parametric mesh generator. This means that you can make a change to a parameter and rerun the commands that form a mesh to get a new mesh reflecting the change. This is a non-trivial feature that affects the way you build the mesh. The Graphical User Interface has been designed so that you can issue commands without parametric considerations. Underlying this simplified use of the commands is a parametric engine waiting for you to discover, once you have become familiar with the basic capabilities. The session file (the default name is tsave) is automatically generated each time you run **True*Grid*®** to record every command needed to reproduce your mesh. This is why you always have the option to run a command file when you start **True*Grid*®**. This is also why there is a keyword command for everything you do in **True*Grid*®**. This is perhaps a subtle distinction, but when a new feature is added to **True*Grid*®**, it is formed as a parametric keyword driven command. Then the Graphical User Interface is added to make it easier to use. The Graphical User Interface is just a shell around **True*Grid*®** and can be bypassed by using the **nogui** option on the execute line.

True*Grid*® generates multi-block structured meshes (see the **block** and **cylinder** commands). Each block is composed of solid hexahedral (six-sided) elements and/or structural quadrilateral shell and beam elements (see the **bm**, **ibm**, **jbm**, and **kbm** commands) arranged in rows, columns, and layers. By collapsing a face or two of a hexahedral brick, one can get a wedge or a tetrahedron as the case may be. A quadrilateral shell can have an edge collapse to form a triangle where the geometry requires it. Typically, one creates a mesh using the block or cylinder part several times and with the requirement that these parts are connected. This is easily done using the block boundary interface commands **bb** and

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

trbb which will glue one block or cylinder to another. These commands can also be used to form one mesh from two independently generated meshes.

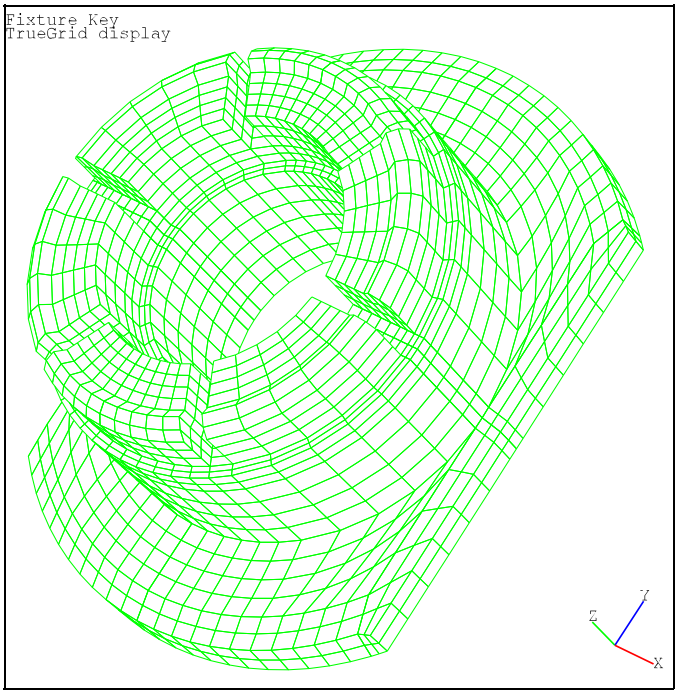


Figure 2 Mesh of Fixture Key

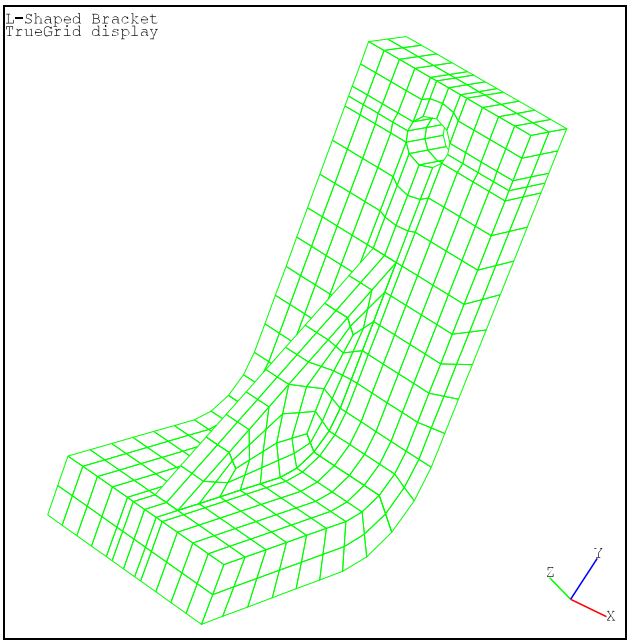


Figure 3 Mesh of L-Bracket

True*Grid*® can generate meshes that match your geometry using various surfaces and curves, such as those defined by you from an extensive built-in library (see the **sd** and **curd** commands). These surfaces and curves can be derived from experimental (see the **vpsd** command and the **lp3** option of the **curd** command) or computational data (see the **mesh**, **face**, and **faceset** options of the **sd** command), from CAD/CAM programs via IGES files (see the **iges** command), or form drawings using algebraic forms (most options of the **sd**, **curd**, and **ld** commands). You can also combine surfaces (see the **sds** option of the **sd** command) and curves (see the **coedge** or the **sdedge** option of the **curd** command). The projection method will place the block structured mesh to intersections or other combinations of surfaces and curves (see the **sf**, **pb**, **mb**, and **curs** commands).

Some of the tools for generating high quality meshes include multi-linear interpolation (see the **lin** command), transfinite interpolation (see the **tf** command), and elliptic smoothing (see the **relax**, **unifrm**, **tme**, and **esm** commands). Diagnostic tools make it easy for you to measure the quality of your mesh (see the **mea** command). Then you can make local or global changes to the mesh to improve the quality, if desired.

True*Grid*® features a graphical user interface that lets you generate your mesh by `pointing and clicking`. Prompts, dialogue boxes, and an on-line help package help you create your mesh. You learn how to use the tool by using it. You can view the mesh as you build it. The arbitrary **undo**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

and **redo** facility lets you easily experiment with modifications to the mesh. These interactive features are designed to give you the fast feedback you need to speed up the mesh generation process.

To know the commands mentioned above is to know the core commands in **True*Grid*®** to generate a mesh. You can easily learn to use the other commands in **True*Grid*®** as the need arises.

2. Availability

Getting Information on True*Grid*®

You can get information or help on **True*Grid*®**'s capabilities, including descriptions of its meshing and geometry methods, graphical user interface, and connections to simulation codes by calling:

(925) 349-6318

or by faxing to:

(925) 826-5745

or by writing to:

XYZ Scientific Applications, Inc.
2255 Morello Ave.
Pleasant Hill, CA 94523

or by e-mailing to:

info@truegrid.com

or by visiting our web site at:

http://www.truegrid.com

Getting a Demonstration Copy of True*Grid*®

Currently, we offer a **True*Grid*®** demonstration program that will run on a Windows PC. This program is available on our home page and shows you several example meshes which are generated using **True*Grid*®**.

In addition, a trial version of our software may be obtained by contacting our office using one of the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

above means. This time-limited trial includes our Tutorial Manual, User's Manual, Examples Manual, Output Manuals, and License Manager Manual which will help you explore **True*Grid*®**'s powerful mesh-generation method and its sophisticated graphical user interface as you generate sample meshes of your own.

Purchasing A True*Grid*® License

True*Grid*® licenses can be purchased on a yearly basis or perpetual (paid-up). Both include any upgrades during the year of purchase. There is an additional cost to maintain **True*Grid*®** beyond the first year for a perpetual license. Call, write or e-mail XYZ Scientific Applications to get pricing or further licensing information on **True*Grid*®**.

3. Installation and Licensing

The installation instructions describes step-by-step how to install and configure **True*Grid*®** for your particular platform and environment. These instructions are included in all distribution downloads from the web and DVDs. Key points for each installation are included here for completeness. Full details can be found in:

Install_WIN.txt or Install_WIN.pdf for the WINDOWS operating systems.

Install_LINUX.txt or Install_LINUX.pdf for the REDHAT LINUX operating systems.

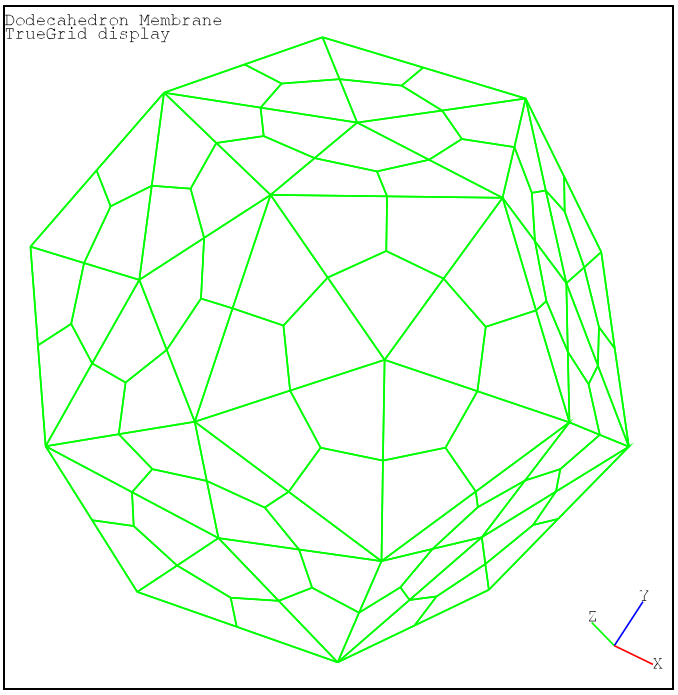


Figure 4 Mesh of Surface of Dodecahedron

If you have purchased a license of **True*Grid*®** recently and the license server (possibly your personal computer) is not authorized to run the latest version of **True*Grid*®**, then the installation (tgauth for LINUX) or the registration program (registration or unlock for WINDOWS) will request an authorization code which must be acquired from XYZ Scientific Applications. You will be asked to send a company name, a check sum, and a machine ID number presented to you by the installation or registration program. In response, XYZ Scientific Applications will return an appropriate authorization code with a new check sum. When this is entered, the machine will be authorized and the **True*Grid*®** License Manager (tglm) will be (re)started. It may be necessary to set the TGHOME environment variable so that the **True*Grid*®** executable program, called tg (for **True*Grid*®** using OpenGL harware graphics), tgd (for **True*Grid*®** in double precision

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

using OpenGL), tgx (for **True*Grid*®** using X WINDOWS), tgdx (for **True*Grid*®** double precision using X WINDOWS), tgw (for **True*Grid*®** using WINDOWS native API graphics) , and tgdw (for **True*Grid*®** double precision using WINDOWS native API graphics) will know where the authorization file, .tgauth, and the related data files are located.

This license manager must be on one machine on your network. Then **True*Grid*®** can be run from any machine on that network. When installing **True*Grid*®** on a machine that is not running the license manager, simply copy the .tgauth file from the licensed machine into the **True*Grid*®** installation directory on this new machine.

For **True*Grid*®** to run, it must be able to find and open the .tgauth file and related data files in the same folder or directory. The installation programs sets up these related data files properly for you, but you can customize it later. When you run tg, tgd, tgx, tgdx, tgw, or tgdw, it immediately looks for these files in a number of places. These places differ a little depending on the operating system.

Learning True*Grid*®

Be sure to read the sections ``**True*Grid*®** Basic Concepts``and ``How **True*Grid*®** Works.`` These sections introduce you to the concepts and notations of **True*Grid*®**.

Also work through the **True*Grid*®** Tutorial manual. This takes you step-by-step through the generation of a model. After this tutorial, you will have the fundamental skills needed to use **True*Grid*®**.

Next, read the section ``Running **True*Grid*®**.`` After reading this section, you will have an understanding of the general sequence of actions you and **True*Grid*®** will perform to generate your mesh. Expand this reading to include the rest of the Introduction and the chapter on the Graphical User Interface (GUI). Some advanced users prefer to type the commands in the text window or create a batch file, but the GUI can be a tremendous aid for the new user.

Finally, look at the documented examples which are provided in the Examples directory along with the distribution. You can use any text editor to view these annotated files while you examine them on the screen. Insert **interrupt** commands in order to pause execution at key locations and then click the ***Resume*** button in order to continue execution. At this point, you should be able to set up simple models with **True*Grid*®**, and modify more complicated models set up by other people.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Using the Manual

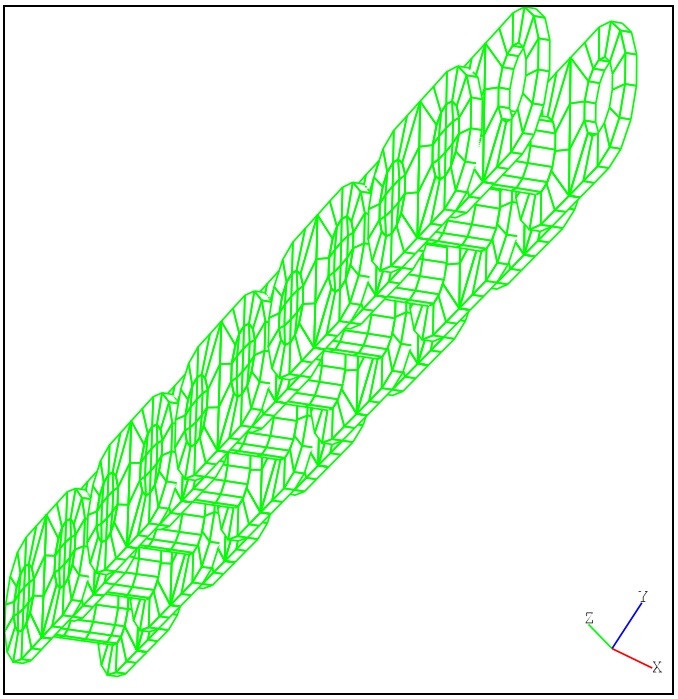


Figure 5 Mesh of a Chain

The manual is organized into seven (7) chapters. This chapter, the Introduction, has basic information on setting up and using **True*Grid*®**. The second chapter describes the Graphical User Interface.

The next four chapters serve as a command reference with complete descriptions of all of **True*Grid*®**'s commands and features. The Part Commands chapter covers the commands that are used to initially generate the mesh and impose constraints, loads, and conditions. The Geometry Commands chapter discusses how you can use **True*Grid*®** to generate and manipulate the geometry of your part(s) prior to attachment or projection. The Assembly Commands chapter describes the means of combining different parts into a complete model, verifying it, and creating a formatted output file. The Global Commands chapter describes commands which can be used in all phases of a model's development. Notice that these first 3 chapters roughly correspond to the three phases in **True*Grid*®** and then the Global chapter contains commands common to all three phases. Global commands are usually setting properties of the model without being specific to elements or nodes.

The last chapter, called Output, is a mixed bag. In some cases this chapter contains the details for keyword commands that are involved in the output, but not specific to one output format or another. In other cases the keyword commands are listed but with no or little details. These commands are specific to one output format or another and are described in detail in another manual. For example, the keyword commands for material definitions and analysis options for ABAQUS will be found in this chapter, but the detailed information about the material models and analysis options for ABAQUS will be found in the "**True*Grid*®** Output Manual to ABAQUS". These output format specific manuals will also contain a list of commands in **True*Grid*®** that set loads, constraints, and other properties specific to that output format.

Not all output options have an associated **True*Grid*®** output manual because their data is (almost) exclusively the mesh and do not warrant a **True*Grid*®** output manual. For a concise list of **True*Grid*®** features associated with an output option, you can use the HELP button after selecting on output option from the OUTPUT menu in the control phase.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

There is a lot to learn, but focus on building the mesh. This is the key. When you get to the point where you also need to set boundary constraints, loads, contact surfaces, properties, and other things, you will be able to do this because the methods you learn to build the mesh carry over to the these other types of commands.

If you know the name of a command and want information on it, the index is the quickest way to find it. If you are looking for a particular capability, you can either look for an appropriate keyword in the index or else try the table of contents. The manual's table of contents is an excellent place to look for a capability since it includes, with every command name, a brief description of what the command is used for.

Getting Help

For help, call (925) 349-6318 or email at info@truegrid.com. If possible, please include an input file which exhibits the difficulty that you are having.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

4. True*Grid*® Basic Concepts

This section will discuss some of the concepts and notations which permeate **True*Grid*®**.

Two Kinds of Mesh

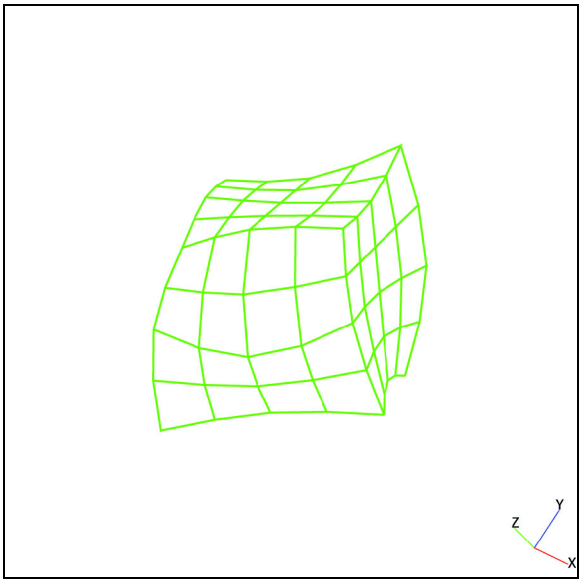


Figure 6 Physical mesh of the Block with spline interpolated edges

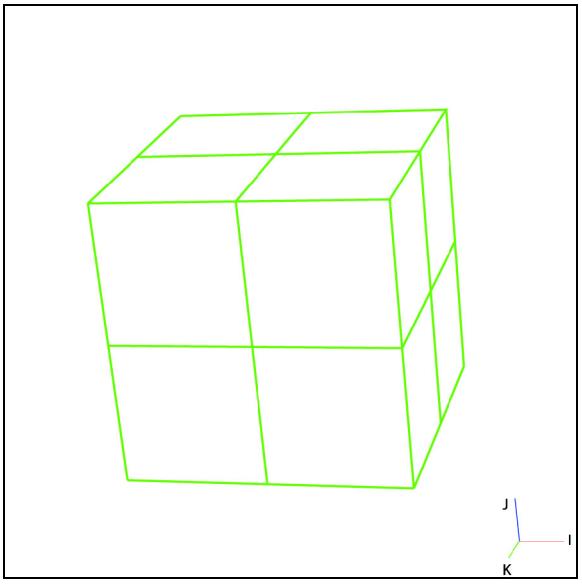


Figure 7 Computational mesh of the Block with 8 SubBlocks

In **True*Grid*®** there are two representations of a mesh: physical and computational (**Figure 6** and **Figure 7**). The physical mesh lies in the physical space where you want to model something, while the computational mesh lies in an abstract space with only integer valued points. There is a correspondence between every node in the computational mesh and the corners of the blocks, usually referred to as vertices or control points, of the mesh You move the physical mesh to fit the real object you are modeling. In contrast, the computational mesh does not move. The computational mesh serves as a convenient way of identifying regions of the mesh which are to be the object of varies functions. Object in the physical space have three coordinates named x, y, and z. Objects in the computational space have three coordinates or indices named i, j, and k. From a mathematical perspective, a mesh is a vector function that maps a three dimensional region (the computational mesh) to a three dimensional region (the physical mesh). Every point in the mesh has six coordinates, three indices and three physical coordinates. We will only be interested in indices with integer values, although one can extend the notion of a computational mesh to all reals for a theoretical discussion.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Making Parts and Merging them into a Model

A typically mesh will be complicated enough that it is easier to build by first making a number of parts and then putting these parts together. Each part begins as a rectangular set of nodes called a block (see the commands **block**, **cylinder**, and **blude**). You can then move (see the commands **pb**, **mb**, **mbi**, **tr**, and **tri**) and deform (see the commands **sf**, **sfi**, **cur**, **curs**, **cure**, **curf**, and **edge**) this simple block structure into the shape of the part you need (**Figure 10**, **Figure 11**, **Figure 12** and **Figure 13**). There are function that control the interpolation (see the commands **res**, **drs**, **as**, **das**, **lin**, **lini**, **tf**, **tfi**, **relax**, **relaxi**, **tme**, **tmei**, **unifm**, and **unifmi**) of interior nodes. Some functions affect the mesh in both physical and computational space, e.g. deleting regions of the mesh (see the commands **de** and **dei**) or making copies (see the commands **lrep**, **grep**, **pslv**, and **pplv**). Once you have made all the parts, you can join them by merging (see the commands **merge**, **t**, **tp**, and **stp**) coincident nodes (**Figure 9** and **Figure 8**).

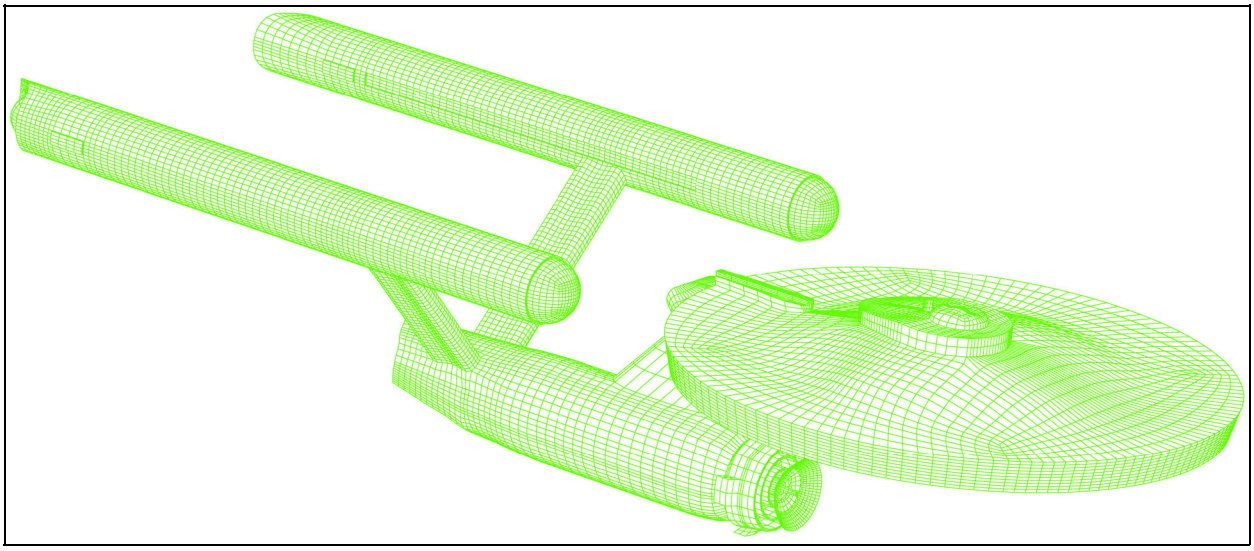


Figure 8 Completed model of fictional spaceship

In **True*Grid*®**, the most important way to deform a simple mesh is with the **sf** or **sfi** commands. This is done, interactively, with the ***PROJECT*** button. For a projection, you specify a region of the mesh and a surface to project it onto. For every node of the region in physical space, **True*Grid*®** will find its projection onto the surface, i.e. the closest point on the surface. That projection point will be the new location of the node in physical space. (See the discussion of the **sf** command for a more precise description.) But **True*Grid*®** is not finished when it has moved the face of a block part. Every other node of the part may have to be moved in order to preserve interpolation and spacing rules.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

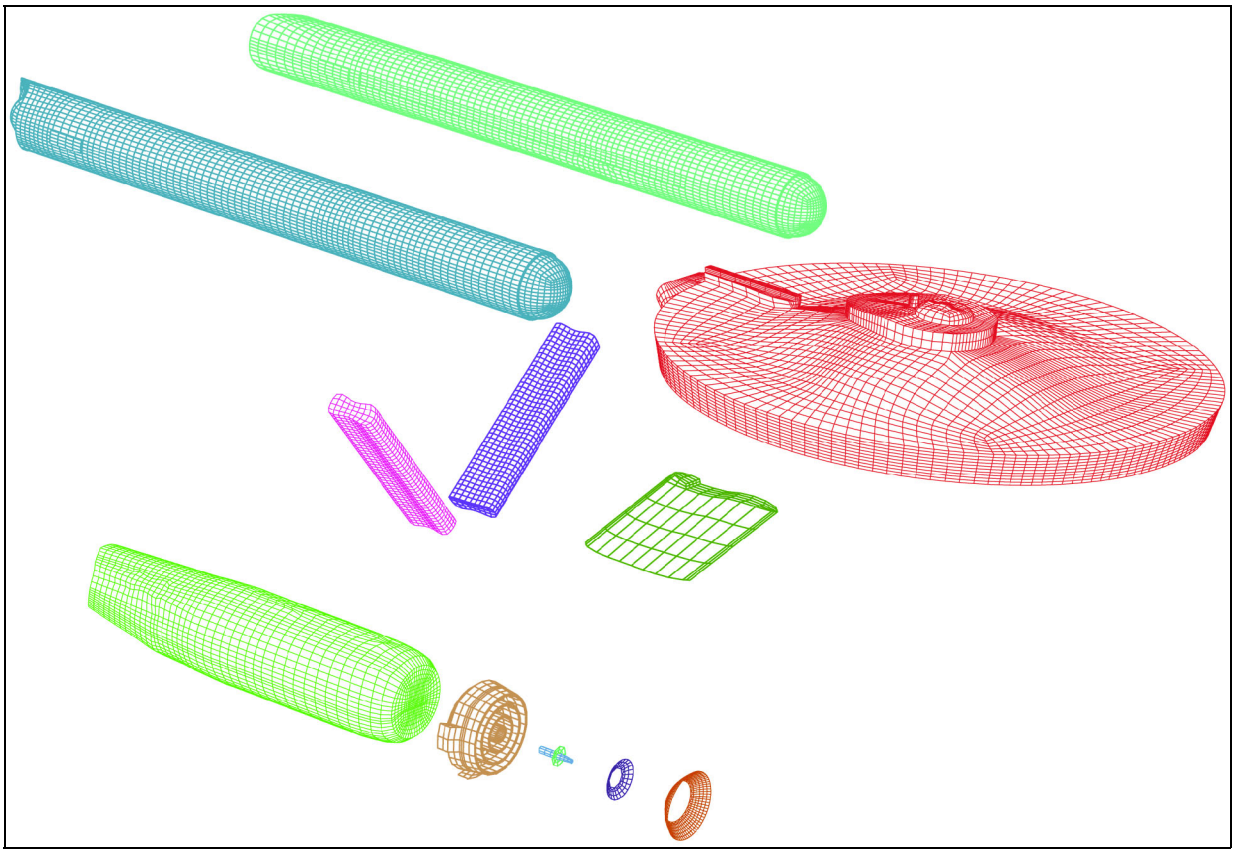


Figure 9 Model of a fictional spaceship, before merging parts

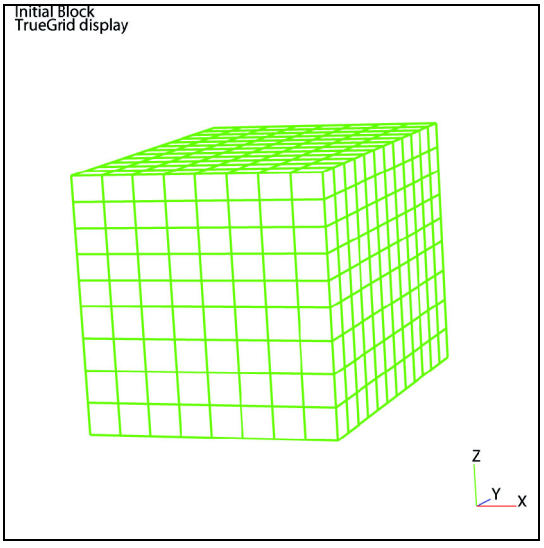


Figure 10 Simple Part before Projections

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

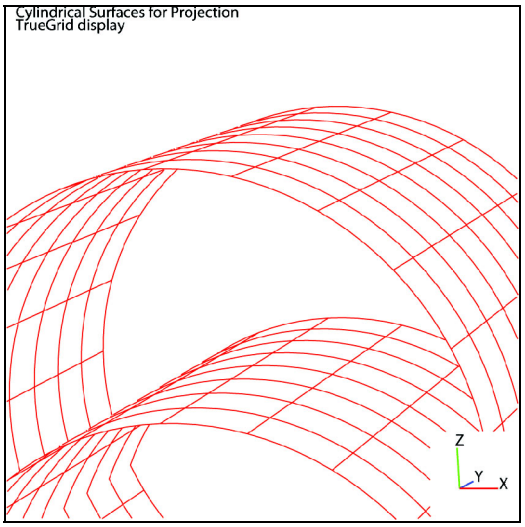


Figure 11 Cylindrical Surfaces

For example, we specified that the upper face of the block in **Figure 10** be projected to the upper cylinder in **Figure 11** in order to get the curved upper face of **Figure 13**. After this surface projection, **True*Grid*®** automatically moved all of the neighboring interior nodes upwards in order to satisfy the interpolation rules.

To repeat, projections are a way to define the shape of a part by placing its face nodes onto surfaces. The interior nodes are placed by interpolation. By default, **True*Grid*®** places interior nodes with a linear interpolation method. This is discussed in detail in the remarks on the **lin** command. You can specify other interpolation algorithms if you prefer. (**Figure 13** was made with the **tf** transfinite interpolation command.)

Regions, Indices, and Reduced Indices

When you define a mesh with **True*Grid*®**, you often refer to a region, i.e. a set of nodes which form a rectangular set in the computational space. A region may be a vertex, edge, face or volume of the mesh.

One of the major notational issues is how to specify a region. We do not want to specify a region directly, by giving the lower and upper limits for its i, j, and k indices. This is because we may later want to change the number of nodes in the mesh. If we specified regions in terms of the actual i, j, and k index values, we couldn't change the number of nodes (see the command **mseq**) without carefully going through the entire mesh specification and changing index values in each of the many places that refer to some region.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

True*Grid*® solves this problem by describing the computational space with two sets of indices at once: full indices and reduced indices.

The indices are the coordinates in computational space and change if you refine the mesh without otherwise changing the shape. The **block**, **cylinder**, and **blude** commands create a three dimension, multi-block structured, rectangular mesh. The numbering of the nodes in each direction is independent, starting with 1. This produces a three dimensional array of nodes. Each node in uniquely identified by the three indices i, j, and k. For example,

```
block 1 5;1 6;1 7; ...
```

creates a simple block mesh of 5 by 6 by 7 nodes in the i, j, and k directions respectively. The semicolon terminates the i, j, and k index lists. The **block**, **cylinder**, and **blude** commands are generalized so that a single part can have any number of connected blocks. These parts usually contains more blocks than are needed for a particular problem. This is because it is usually easier to define an array of blocks and delete some of them then it is to define each required block separately. For example:

```
block 1 5 9;1 6;1 7; ...
```

has 2 blocks in the i-direction, each with 4 elements between the nodes.

The **block**, **cylinder**, and **blude** commands are some of only a few commands that refers to the actual nodes in the mesh. Once one of these commands creates a multi-block part, the subsequent commands refer to regions in the mesh by using the sequence number in the i, j, or k-list of one of these commands. These sequence numbers are referred to as reduced indices. In the example above, a reduced i-index can have a value of 1, 2 or 3. The reduced indices in the j and k-directions can have a value of 1 or 2. The numbers in the i, j, and k-lists of the **block** command subdivide the mesh. These sub-divisions are sometimes referred to as partitions of the mesh. These reduced indices are essentially numbered parameters referencing back to the node numbers in the initial part command. This is an important parametric feature of the **block**, **cylinder**, and **blude** commands. To change the mesh density, you need only change the lists in these commands. All other commands that have been issued will be automatically adjusted. There are two ways to make such a change: issue the **mseq** command or end your **True*Grid*®** session, modify the session file, and rerun the session file as a command input file.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

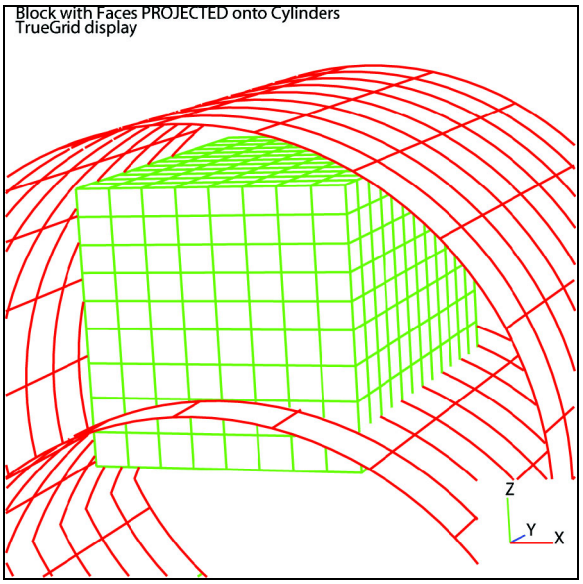


Figure 12 Simple Block and Projection

When you first set up a part with the **block** command, you give a value of an i, j, or k index for every i, j, or k reduced index that you will use. For example, the code

```
block 1 10 20 ;
      1 20 ;
      1 100 200 300 ;
      0.0 1.0 2.0
      -10.0 12.5
      0.0 10.1 20.1 30.1
```

defines a part to have 20 nodes in the i direction, 20 in the j direction, and 300 in the k direction for a total of 120,000 nodes. The reduced indices in i are 1, 2, and 3, and represent i coordinates (indices) 1, 10, and 20. In j the reduced indices are 1 and 2 for j coordinates 1 and 20. In k the reduced indices are 1, 2, 3, and 4 for k coordinates 1, 100, 200, and 300. The rest of the command defines the corresponding nodes in physical space.

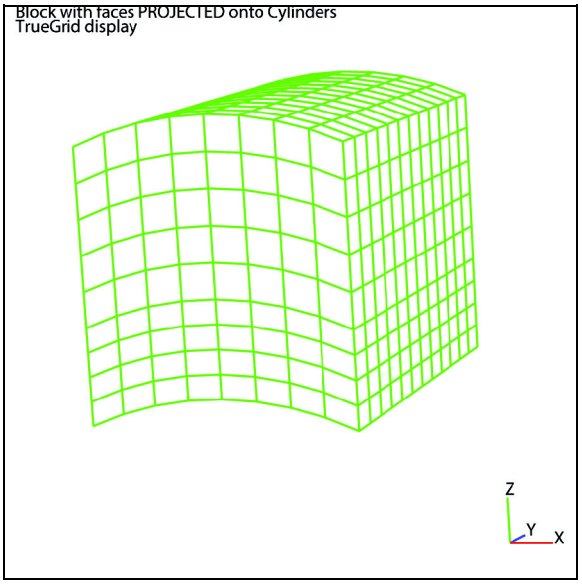


Figure 13 Completed Part: a Block with Upper and Lower Faces Projected to Cylinders

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

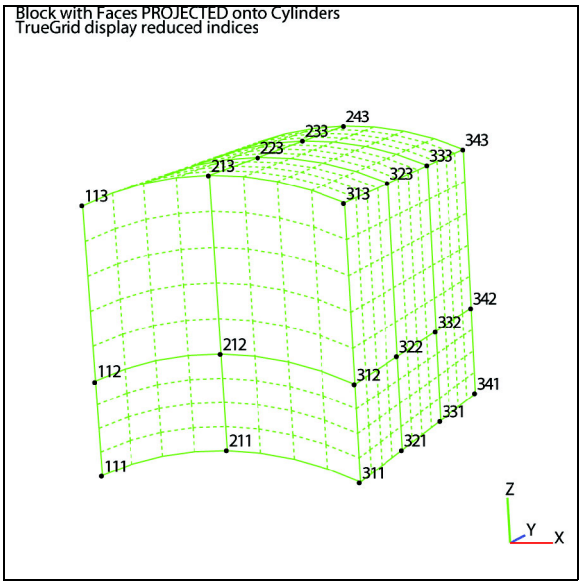


Figure 14 Completed Part: a Block with Two Faces Projected to Cylinders; Showing Values of Reduced Indices in i, j, and k directions

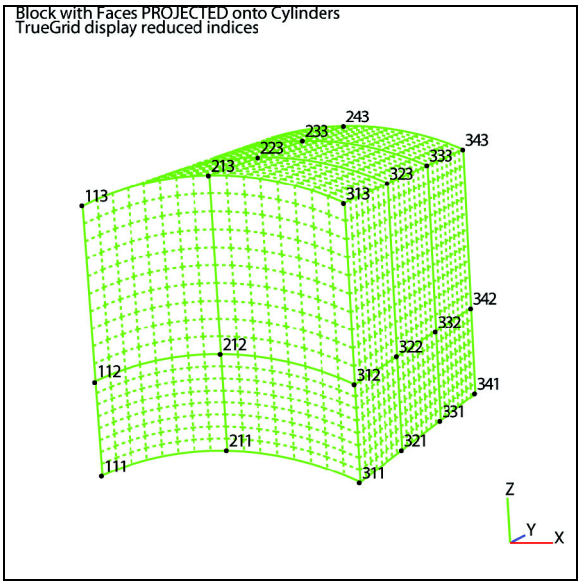


Figure 15 Finely Meshed Part: a Block with Two Faces Projected to Cylinders; Showing Values of Reduced Indices in i, j, and k directions

You do not have to determine the reduced indices when you select a region or regions using **True*Grid*®**'s Graphical User Interface (GUI). You choose the regions graphically using the mouse and let the GUI interpret your graphical selections in terms of reduced indices, which it passes on to the **True*Grid*®** commands. You can specify a region by giving the minimum and maximum values of its reduced indices in all three directions, in the form

$$i_{min}\ j_{min}\ k_{min}\ i_{max}\ j_{max}\ k_{max}.$$

In **Figure 9** and **Figure 15**, the lower left corner of the front face is the reduced index region 1 1 1 2 1 2. The right half of the block is the region 2 1 1 3 4 3. A reduced index region has non-negative integers.

True*Grid*® has a special interpretation of a reduced index of 0. 0 means the extreme value of an index. For example, in **Figure 14** and **Figure 15**, the lower front edge has fixed reduced indices j=1 and k=1, so it could be represented either as 1 1 1 3 1 1 or as 0 1 1 0 1 1.

Notice that **True*Grid*®** has a powerful connection between the graphical selection of a region and its specification with reduced indices. Having highlighted a particular region, you can print out the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

corresponding reduced indices by hitting the **F1** function key. If you have clicked on a command from the menus so that a dialogue box is showing, if the command requires a region selection, then hitting the **F1** Function key will cause the graphical selection of a region to be entered into the dialogue box. An advanced user will typically type the name of a command into the text window, highlight the region which he or she wishes to act upon, hit the **F1** Function key, and then type the rest of the command.

5. How True*Grid*® Works

You mesh an object in the way an artist molds a block of clay. The raw material is a multiple block structured mesh. Some blocks can be removed to place holes in the mesh. Then faces of the mesh are given shape. By default, nodes are equally spaced along edges. Functions can be selected to control the distribution of nodes along edges of the mesh. By default, edges, faces and interiors of blocks of the mesh are automatically interpolated. Alternative interpolations of the interiors of faces and blocks can be selected. You have the control you need with the minimum complexity.

Topology Of The Mesh

True*Grid*® generates block structured meshes consisting of hexahedron 3D solid elements, aligned in rows, columns, and layers to form a block. Each row has the same number of elements. Likewise, each column has the same number of elements and each layer has the same number of elements. You can imagine a block mesh by slicing a rectangular block at regular intervals along each of the three coordinate axis. This block mesh is the basic component in building complex meshes. A part can consist of many blocks. It is also possible to generate 2D shell elements. 1D beam elements can also be generated by embedding them within the solid or shell elements. Additionally, the solids of shells can then be removed.

Full Indices

Each node in a block mesh can be identified by three indices. The first index, referred to as the i-index, identifies the sequence number of the slice in the mesh along the first coordinate axis. The second, j, and third, k, indices are defined in a similar way. These three indices are known as the full indices of a node.

Shape Of The Mesh

A block structure simplifies the mesh generation problem by automatically filling in a block with the required hexahedron elements. You need only specify the shape of the exterior faces of the block mesh. These surfaces are specified using the **sd** command, by importing surface geometry from a CAD/CAM IGES file, or from a polygon surface using the **vpsd** command. Then, each face of the block mesh can be projected to a surface using the **sf** command. This deforms the initial block mesh to the required

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

shape.

Alternatively, you can generate a block mesh using three-dimensional curves. A block mesh has twelve edges, and you can place some of these edges onto 3-D curves. The shape of the curve can be defined using the **curd** command or by importing curves from a CAD/CAM IGES file. Then you can use the **curs** command to place an edge of the block onto the curve. **True*Grid*®**'s prescribed ordering will place edges of the mesh onto 3-D curves before any regions are projected onto surfaces. Neither curve attachments nor surface projections may be required for a particular mesh.

The projection method is a collection of techniques used to place nodes of the mesh onto surfaces. When a node of the mesh is projected onto a surface, it is moved to the point on the surface which is closest to the initial position of the node. It may be necessary to project a node onto two surfaces simultaneously. This is commonly the case for nodes along an edge of the block mesh. **True*Grid*®** automatically detects this condition and projects the node to the closest point on the intersection of the two specified surfaces. In the extreme case, a node can be projected onto three surfaces simultaneously. This is commonly the case for the eight vertices or corners of the block mesh. **True*Grid*®** automatically detects this condition and finds the closest point of intersection of the three surfaces.

Let us look at this last case a bit more thoroughly. In most cases, the three surfaces intersect at a single point, making it the obvious point of projection. It is also possible for three surfaces to intersect at many points, to intersect at an infinite number of points, or to not intersect at all. **True*Grid*®** locates the point of projection with an iterative Newton method which produces a point that minimizes the sum of distances from the node to the surfaces. This method works best when sections of the surfaces nearest the initial point are relatively flat. As with most non-linear problems, the point of projection may only be a local minimum sum of distances (not the true, global solution). For this reason, you may need to position some key vertices of the mesh close to the desired intersections.

Part Initialization

There are numerous ways to position the nodes at the vertices of the block mesh. At this point, we introduce the **cylinder** command. It is like the **block** command except the coordinates are interpreted as radius, angle, and z. The arguments to the **block** and **cylinder** commands include the coordinates to the vertices of the block mesh. In a simple mesh, you may provide those arguments and do no more. But there are several other ways by which you can control initialization. The **pb** command will replaces coordinates of a region. The **mb** command modifies the coordinates of a region. The **pbs** command matches the coordinates of a region to a point on a surface or 3-D curve. The **tr** command transforms the coordinates of a region. All of these functions are invoked when you use the mouse to move the mesh. You can use these commands to make corrections to the coordinates of the regions even after edges have been attached to curves or faces have been projected onto surfaces. After you make corrections to the initial coordinates, **True*Grid*®** will automatically re-attach edges onto curves and re-project faces onto surfaces.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Projection Method

More will be said about the surface intersection algorithms, but this requires a more thorough discussion of the projection of a node onto a surface. The ideal case is when the surface is smooth and has no boundaries. Suppose a node is initially located somewhere off of the surface. A projection of that node onto the surface will be a point on the surface. The line connecting the original node with its projection onto the surface is orthogonal to the tangent plane of the surface at the point of projection. It is possible that there are many points of projection. In that case, **True*Grid*®** will select the one closest to the initial position of the node. In some cases, it is considered an error if there is more than one such point with the shortest distance. For example, an error occurs when a node is initialized to be at the center of a sphere and projected onto the sphere.

This notion of projection onto a surface must be improved for three important cases. Surfaces may have boundaries, they may not be smooth, and they could even be discontinuous. For example, a NURBS surface will have boundaries. A 2-dimensional polygonal line rotated about an axis will not be smooth where the polygonal line segments meet. It is possible to define complex surfaces by combining several surfaces. These surfaces may not meet perfectly or they may overlap. In this case they form a surface which is not continuous. In all three of these cases, **True*Grid*®** defines the point of projection to be a point on the surface with the shortest distance to the projected node.

In addition to finding the point of projection onto a surface, **True*Grid*®** must determine the tangent plane at that point of projection. This is not possible at a point where the surface is not smooth. In this case, the tangent planes in the neighborhood of the point are averaged.

Advantages of the Projection Method

There are important advantages to the projection method, compared to the typical mesh generator using a mapping method. Most importantly, the surfaces do not have to meet perfectly for the projection method to work. This means that if your geometry is coming from a CAD/CAM system or a Solids Modeler, the small gaps between the surfaces or the small overlaps do NOT need to be cleaned. In figure 17, the two surfaces outlined in red do not meet perfectly. And yet the mesh projected to the two surfaces in figure

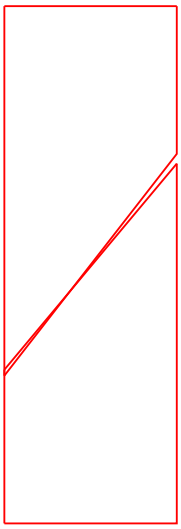


Figure 16
2 surfaces

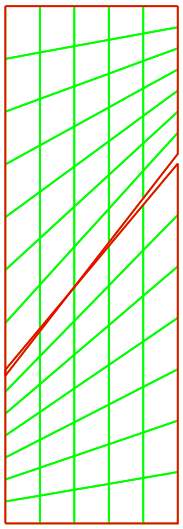


Figure 17
mapping

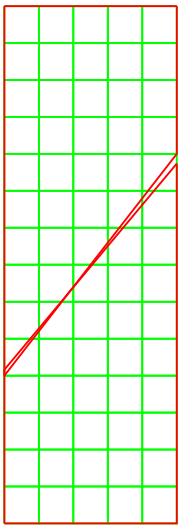


Figure 18
projecting

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

19 are unaffected by these imperfections. On the contrary, figure 18 shows the problems when using the standard mapped mesh technique. The mapped meshes will overlap or have gaps wherever the surfaces overlap or have gaps. Merging these nodes across these imperfections may be easy in this case, but one can imagine worse cases where merging would be difficult. Many mesh generators would not accept this flawed geometry.

Figure 19 demonstrates the need to combine surfaces. The projection method makes this a triviality. A composite surface is simply a set of surfaces. When a surface is projected to a composite surface, its nodes are simply projected to each of the surfaces and then moved to the projection which is closest to the original position of each node. No changes are made to the surfaces. One simple command, **sd** with the **sds** option, is used in **True*Grid*®** to form a composite surface. Without the projection method and composite surfaces, one would have to settle for meshing each surface separately which may form badly shaped elements like those in figure 18.

A less obvious feature of the projection method is that a face of the mesh, projected to a surface or a composite surface, need not cover the entire area. In fact it is more common for a face of the mesh to be projected so that it does not cover the entire area. In contrast, the mapped method requires that an entire surface be meshed. In addition, there must be 6 surfaces, one for each face of a block and each surface must be meshed.

Essentially, if a mapped mesh method is used to create a block structured mesh, the burden is placed on the creation of the geometry. The projection method removes this burden, making it possible to place any block structure onto any set of surfaces.

Surface Intersection Method

The surface intersection algorithms require only a node's point of projection onto a surface and the tangent plane at that point. The most important cases are when a node is projected onto three or two surfaces. In the former case, the node is projected onto all three surfaces. The point of intersection of the three corresponding tangent planes is determined and the node is then moved two-thirds of the way towards that point. This is repeated until it converges to the intersection of the three surfaces.

When a node is projected onto only two surfaces, there are only two points of projection and two tangent planes. But **True*Grid*®** finds the intersection just as described above, except that, in place of the third tangent plane, **True*Grid*®** uses the plane which passes through the node point and its two points of projection.

This method works because a tangent plane forms a local approximation to a surface. This is an example of a classic iterative Newton method. When the surfaces have large curvature, you should take care to initially locate the node close to the point of intersection.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

An edge of the block mesh is a row of nodes between two neighboring vertices of the block mesh. **True*Grid*®** calculates edges of the mesh after placing all of the vertices onto the specified surfaces. The edge nodes are usually placed onto 0, 1, or 2 surfaces. They can be equally spaced or distributed using a geometric progression. **True*Grid*®** does this in two steps. First the nodes of the edge are distributed along the line connecting the end points of the edge (the end points are already in place). The second step is an iterative process. **True*Grid*®** projects each node onto the required surfaces in the manner described above. Then the nodes are all perturbed in order to satisfy the spacing requirement. Since this perturbation may have moved some of the edge nodes off of the required surfaces, the edges are again projected onto the required surfaces. This process is repeated until all of the constraints are satisfied.

A special case exists when the edge is required to be on only one surface. If the surface is not too curved, then **True*Grid*®** constructs a plane passing through the two end points of the edge and perpendicular to the surface. The edge nodes are then constrained to fall along the intersection of these two surfaces.

Once the edges of the block mesh are in place, then the faces of the block mesh are calculated. Each face is bounded by four edges of the mesh. The shape of the four edges are blended to form the initial shape of the face. Each node of the face of the mesh is then projected from this initial position to the required surface.

After the six faces of the block mesh are calculated, then the interior nodes are calculated by blending the shapes of the 6 bounding faces.

Command Hierarchy

In **True*Grid*®**'s mesh generation algorithm, each event occurs in a prescribed order. You may issue commands in an arbitrary order. First **True*Grid*®** initializes the vertices. Then it attaches vertices to the required curves and projects them to the required surfaces. Next **True*Grid*®** interpolates the edges, attaches then to the required curves, and then projects them to the required surfaces. Thereafter **True*Grid*®** interpolates the faces and projects them to the required surfaces. Finally, **True*Grid*®** interpolates the interior nodes. For a complete description of the command hierarchy, see the Geometry section of the Generation chapter.

Multiple Block Structured Parts

True*Grid*® includes many generalizations and extensions of the basic ideas discussed above. The most important is the ability to generate a single part by combining many structured block meshes. A block in such a part will normally share nodes with other blocks. One way to set up such a part is to generate each block separately, and then merge the nodes to connect the blocks. If this is to be done, it is

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

important that the nodes in the blocks that are to be merged have nearly the same coordinates. This duplicate effort makes mesh generation more complicated than it needs to be. A better way to set up a multi-block part is to generate the blocks together, as a part having common nodes from the start.

A multiple-block part requires some planning. First, imagine the part as embedded in a large block of clay. You chisel away some rectangular blocks with the **de** command, thus revealing a very coarse approximation to the geometry of the part. By removing small blocks from a big block, you get the same result as from gluing together other little blocks, but it is easier to cut away than to glue. Next, apply the **sf** command to project onto a surface each exposed face of the remaining blocks. This is like molding the blocks into the shapes you need. While shaping the surfaces, you may also want to adjust the locations of a few vertices in order to get a very high quality mesh. You can do all of these things interactively, so it is very easy to check that each step of the process is going right.

When you make a multi-block mesh, each block is interpolated independently. Sometimes you can get a smoother mesh by telling **True*Grid*®** to interpolate across several blocks, ignoring the partitions between them. You can do this with the **lin** command. Several adjacent faces of several blocks can be interpolated, using this bi-linear blending method, as though they formed a single face of a single block.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Quality Meshes

Often you may find that **True*Grid*®**'s optional interpolation and relaxation algorithms will give you a better quality mesh.

The transfinite interpolation command **tf** is one of the best methods of interpolation. It is most useful when the bounding edges have large curvature and when geometric nodal distributions are extreme along the edges of the face. Transfinite interpolation tries to enforce the same relative spacing along the mesh contours in the interior of a face.

The **relax** command invokes the iterative equipotential relaxation smoothing method. This has almost the opposite effect of transfinite interpolation. After many iterations, all the elements tend to take on the same size, except for elements near the boundary. This elliptic method gently shifts only the interior nodes to form a smoother mesh on the interior. This is done by solving the Laplace differential equation along both sets of mesh contours of a face. The edge nodes form the boundary conditions for solving this system of differential equations.

Algebraic Methods

In the last phase of the part generation, **True*Grid*®** evaluates all equations and modifies the mesh accordingly. You use the **dom** command to specify the domain or region of the mesh affected by an equation. Your equation will move each node within this domain. In your expression, you can use the nodal indices **i**, **j**, and **k** and the nodal coordinates **x**, **y**, and **z**. When **True*Grid*®** evaluates the expression, it assigns the result to one of the node's coordinates. For example:

```
x = x + j * z / 10.1
```

will move the x-coordinate of each node by an amount that depends on the node's **j**-index and **z**-coordinate.

For more complicated systems of equations, you can use the temporary variables **t1**, **t2**, and **t3**.

This is a very powerful method for generating complex meshes. But it is easy to make a mistake in the algebra and produce a mesh that has no physical meaning. So use this feature with great care.

Interactivity

When you generate a mesh interactively, every mesh generation command potentially requires **True*Grid*®** to recalculate the whole mesh. This is because the new command may have to be executed early in the mesh generation process (i.e. in the command hierarchy), affecting the execution of the other

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

commands. **True*Grid*®** does not actually recalculate the mesh until you issue a new graphics command. This way you can issue several new commands before **True*Grid*®** recalculates the mesh, greatly reducing the number of calculations. How much time **True*Grid*®** takes to recalculate the mesh can vary with the size and complexity of the mesh and the speed of the computer.

You can look at the history table to review the mesh generation commands in **True*Grid*®**'s command tables. You also can deactivate a command that you find in the history table. This will also force **True*Grid*®** to recalculate the mesh. And if you reactivate a deactivated command, then once again **True*Grid*®** will have to recalculate the mesh.

Specifying Multiple Blocks

In order to make a standard part with multiple blocks, you have to specify three lists of node numbers, for the three computational indices, i, j, and k. Each list tells **True*Grid*®** the nodal position of each partition between blocks. In other words, it gives the i-, j-, or k-index for each boundary between blocks. For example:

```
block 1 3 5 7 ; 1 4 9 ; 1 21 ; . . .
```

creates a part with six blocks. Each list starts with a 1 and ends with a semi-colon. The first list of integers above indicates that there are 7 nodes in the i-direction in the computational mesh. The integers 3 and 5 define two partitions at nodes 3 and 5. This means that there are three blocks in the i-direction in the computational mesh, where each block is two elements wide. The second list creates two blocks. The first block starts at node 1 and ends at node 4 in the j-direction of the computational mesh. The second block starts at node 4 and ends at node 9. There are no partitions in the k-direction, with 20 elements in the third direction in the computational mesh.

It is useful to think of the beginning and ending of the part in each of the three directions as terminal partitions.

To summarize, this example is 3 blocks wide in the i-direction, 2 blocks wide in the j-direction, and 1 block wide in the k-direction.

Initial Coordinates

The **block** command creates a part in a local 3-dimensional Cartesian coordinate system. These three coordinates are called **x**, **y**, and **z**. In the **block** command and other commands, you specify not only the computational mesh but also the corresponding physical data. In the **block** command, after the three lists describing the part in the computational indices i, j, and k, you provide another three lists describing the part's initial position in the local physical coordinates x, y, and z. For example, the full version of

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

the above **block** example is:

```
block   1 3 5  7   ;        1   4     9   ;      1  21   ;
      0 0.1 0.3 0.7 ;     100 100.2 100.8 ;    -1  -3.1 ;
```

In this example, each node with an i-index of 1 is assigned an x-coordinate of 0. Each node with i=3 will have x=.1, each node with i=5 will have x=0.3, and each node with i=7 will have x=0.7. Similarly, each node with j=1 will be assigned y=100, j=4 will have y=100.2, j=9 will have y=100.8, k=1 will have z=-1, and k=21 will have z=-3.1. This creates 6 rectangular blocks, which fit neatly together to form a larger rectangular block.

More generally, as the first three lists give the i-, j-, and k- indices for the mesh partitions, the second three lists give the initial values of the x-, y-, and z- coordinates for these partitions. Just as each number in the first three lists specify planes which form the partitioning of the computational mesh, so do the second three lists define planes which form the initial position of the partitions in the physical mesh. The x list has exactly one real number for every integer in the i list, the y list has exactly one real number for every integer in the j list, and the z list has exactly one real number for every integer in the k list. Every partition is specified both as an i-, j-, or**k**- index value and as a plane in the physical space.

Cylindrical Coordinate Systems

The **cylinder** part is just like the **block** part except for its local coordinate system. For the **cylinder** part, the three physical coordinate lists correspond to the radial, angular, and axial coordinates, respectively. Although these coordinates are conventionally called r, θ, and z, **True*Grid*®** documentation calls them x, y, and z (the same as for **block** parts), for brevity. For any part phase command defining a **cylinder** part, **True*Grid*®** interprets all coordinate parameters in terms of cylindrical coordinates. In the cylindrical part, **True*Grid*®** carries out all interpolations in cylindrical coordinates.

Mesh Density Parameterization

The **block**, **cylinder**, **blude**, **insprt**, **meshscal**, and **mseq** commands are the only commands that control the number of nodes in each block of the part. The **block**, **blude**, and **cylinder** commands initiate a part and place **True*Grid*®** into the part phase. The **insprt** and **mseq** commands can only be issued in the part phase after issuing the **block**, **blude**, or **cylinder** command because they essentially modify the preceding the **block**, **blude**, and **cylinder** commands by changing the topology and the mesh density, respectively. The **insprt** and **mseq** commands are exceptional part phase commands. All other part phase commands use indirect references to the indices in the **block**, **cylinder**, or **blude** commands, know as reduced indices, to select vertices, edges, faces, and blocks of the mesh. This indirect reference to regions of the mesh adds complexity which is warranted because with this comes the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ability to change the mesh density by adding or modifying just one command. Either the **block**, **blude**, or **cylinder** command can be modified or the **mseq** command can be added to change the number of nodes within a block of the mesh. The **meshscal** command at the beginning of the input can be used to scale the number of nodes in all parts.

Reduced Indices

Most **True*Grid*®** commands that refer to regions of the mesh use reduced indices. With reduced indices you reference each partition in the **i**-direction of the mesh by its sequence number in the first list of node numbers in the **block**, **blude**, or **cylinder** command. The same referencing scheme applies to the partitions in the **j** and **k**-directions. In order to identify a vertex (i.e. a corner node of a block within the part), you provide its three partition sequence numbers, one in each direction. These three numbers are the reduced indices of the vertex. Notice that since you can only reference reduced indices, it is important that you initially define these reduced indices to correspond with those features of the part which you may wish to manipulate.

Vertices and Regions

A vertex is a node that can be selected using reduced indices. This definition is equivalent to saying a vertex is a corner of a block. These are the handles on the mesh and can be described as control nodes of the mesh. A few commands require the reduced indices of a vertex. For example, the **q** command assigns the coordinates of one vertex to another.

q target_i target_j target_k source_i source_j source_k

The vertex with the i, j, and k reduced indices target_i target_j target_k are assigned the same coordinates of the vertex with the i, j, and k reduced indices source_i source_j source_k. For example:

```
block 1 4 9;1 3;1 5;0 .3 .8;0 .2;0 .4;
q 1 2 1 2 1 2
```

will move the node at reduced indices (1,2,1) to the same position held by the node with reduced indices (2,1,2). Based on the **block** command that precedes the **q** command, substitutions can be made for the reduced indices. It can then be said that the node with the full indices (1,3,1) is moved to the same coordinates held by the node with full indices (4,1,5).

Many commands require you to specify a region by providing its minimum and maximum reduced indices in all three directions. For example, the **lin** command uses the boundary coordinates of a region to interpolate the interior.

lin $\mathbf{i}_{\text{minimum}}$ $\mathbf{j}_{\text{minimum}}$ $\mathbf{k}_{\text{minimum}}$ $\mathbf{i}_{\text{maximum}}$ $\mathbf{j}_{\text{maximum}}$ $\mathbf{k}_{\text{maximum}}$

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This notation can be used to select a block, face, edge, or single vertex. If the linear interpolation command below was issued after the block command above, then it would cause a block interpolation of the entire part.

```
lin 1 1 1 3 2 2
```

The reduced indices of the region in the i-direction start at 1 and end at 3. This is the entire range of the reduced index in the i-direction. Both the reduced j and k-indices of the region span from 1 to 2, which is also their entire range. The nodes on the exterior faces form the boundary data used to interpolate all of the interior nodes of the part. The one interior face which forms the interface between the two blocks has all of its interior node interpolated as well.

A face is selected if the minimum and the maximum reduced indices in exactly one of the i, j, or k-direction are the same number. If the two reduced i-indices are the same, it is referred to as an i-face. Similarly, if the reduced j or k-indices are the same, it is referred to as a j or k-face, respectively. The following example of a k-face interpolation causes the interior nodes of the face to be interpolated, based on the coordinates of the exterior boundary edges of this face. The interior edge between the two component faces, where the reduced i-index is 2, is included as interior nodes of this linear interpolation.

```
lin 1 1 1 3 2 1
```

If two pairs of reduced indices are have the same numbers, then an edge is selected. For example, if the reduced j-indices are the same and if the reduced k-indices are the same, while the reduced i-indices are not the same, then an i-edge has been selected. If the reduced j-indices are not the same, it is referred to as a j-edge. A k-edge is defined in a similar manner. For example,

```
lin 1 1 1 3 1 1
```

the i-edge, starting at the reduced i-index of 1 and ranging to 3. The two end vertices form the endpoints of a linear sequence of nodes in the i-direction. The interior vertex with reduced i-index of 2 is also treated as an interior node of interpolation.

Note that the **lin** command for linear interpolation is not useful except when applied to more than 1 block, face, or edge. This is because the **lin** function is the default interpolation. It is used as an example because it is one of the most basic functions. Also note that the command,

```
lin 2 1 1 2 1 1
```

which selects a vertex, has no meaning as a linear interpolation. It is mentioned here for completeness.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

When all three pairs of reduced indices are the same (i.e. both reduced i-indices are the same, both reduced j-indices are the same, and both reduced k-indices are the same), a single vertex is selected.

0 has a special meaning. If you provide 0 as the minimum reduced index, **True*Grid*®** will use 1. If you provide 0 as the maximum reduced index, **True*Grid*®** will use the maximum reduced index in that direction. This feature is most useful when you want a reduced index to range over *all* possible values in some direction. Then you simply use 0 for both the minimum and the maximum reduced index.

Index Progressions

Index progressions are a concise notation used to describe complex objects in the mesh. An index progression consists of three lists of signed reduced indices, an i-list, a j-list, and a k-list, with each list ending with a semi-colon. A simple example is when a region is converted to an index progression.

```
lini 1 3;1 2;1 2;
```

This example selects a region by selecting the range in the reduced i-index from 1 to 3. Both the reduced j and k-index range from 1 to 2. It is typical that a function, like **lin**, has two forms, one used when a region is selected and the other used when an index progression is selected. The index progression version of a command has the letter i at the end of the command.

Index progressions are useful when multiple regions are selected. 0 is used to indicate the union of several regions. For example,

```
lini 1 3 0 4 6;1 2;1 2;
```

this command is the union of two regions. It can be replaced by the two commands

```
lin 1 1 1 3 2 2
lin 4 1 1 6 2 2
```

In fact, any index progression can be converted to a set of regions. When a 0 is used in more than one index progression list, the equivalent list of regions is the product of selections in each index direction. For example,

```
lini 1 3 0 4 6;1 2 0 5 7;1 2;
```

is equivalent to

```
lin 1 1 1 3 2 2
lin 4 1 1 6 2 2
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
lin 1 5 1 3 7 2
lin 4 5 1 6 7 2
```

Faces are selected in an index progression using a minus sign. For example,

```
lini 1 3;-1;1 2;
```

is equivalent to

```
lin 1 1 1 3 1 2
```

Multiple faces can be selected with one index progression. Index progressions can be complex and a systematic way to understand them is to first consider the index progression without the minus signs. For example,

```
lini -1 -3;1 3 0 -4 7;1 2;
```

is easily understood by first considering the two blocks selected if the minus signs are ignored. Then each minus sign selects the corresponding face(s) in one or both blocks. When a face of a block is selected, using a minus sign, the block is not selected. The above example is equivalent to

```
lin 1 1 1 1 3 2
lin 1 4 1 1 7 2
lin 3 1 1 3 3 2
lin 3 4 1 3 7 2
lin 1 4 1 3 7 2
```

Edges of blocks are selected by using minus signs for all indices in two directions and no minus signs in the third. Also, multiple indices in the two directions with minus signs must be separated with zeros. For example,

```
lini -1 0 -3;-2;2 4 0 6 8;
```

selects 4 k-edges and is equivalent to

```
lin 1 2 2 1 2 4
lin 1 2 6 1 2 8
lin 3 2 2 3 2 4
lin 3 2 6 3 2 8
```

Multiple vertices can be selected by using the minus sign for all indices in all directions, separating the indices with zeros. For example,

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
lini -1 0 -2;-1 0 -2;-1 0 -2;
```

selects all 8 vertices of a block. Again, it should be noted that linear interpolation has no meaning when applied to vertices, but is included here to complete the theme of this discussion. If this command were issued, it would cause an error.

Graphical Version of Index Progressions

The computational window is provider to make the selection of regions more intuitive. Experienced users become very efficient using this graphical device. A more complete description of the functions associated with the computational window can be found in the chapter on the graphical user interface.

This window displays a representation of all of the blocks forming the part. A cube is used for each block. Along the boundaries of this window are three index bars, one for each of the i, j, and k reduced indices. Each bar has a sequence of nodes corresponding to the i, j, and k- indices found in the **block**, **blude**, or **cylinder** command.

One can select a region of the mesh by a click-and-drag motion with the mouse from one node of an index bar to the next. When a selection of this type is made, the bar within that region turns from green to red. One can also select a partition of the mesh with a mouse click on one of the nodes of an index bar. This selected node will then turn red. Both types of index bar selections can be reversed by repeating the procedure. Alternatively, use the function key **F2**. Typically, such a selection is made in all three index bars. The region of the mesh being selected is then the result of the intersection of the selections made in all three index bars.

There is a one-to-one correspondence between index progressions and objects that can be selected in the computational window. There are three index progression lists corresponding to the three index bars in the computational window. An interval from one reduced index to another within an index progression corresponds to an interval selected along an index bar. A negative reduced index in an index progression corresponds to a node selected on one of the index bars.

When a single region is selected, it can be used in a command such as **lin** where a single region is required. When more complex objects are selected in the computational window, then an index progression is generated and can only be used with commands such as **lini** with the i suffix. After selecting objects in the mesh, the function key, **F1**, is used to submit the selection. If a dialogue box was activated, then the selection will be directed to the dialogue box. Otherwise, it will be directed to the text window.

There are a number of rules and properties to keep in mind when using the computational window to generate an index progression:.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

0. If nothing is selected, then all of the index intervals along an index bar are implied.

1. Points only, selected in all 3 bars, will produce vertices.

2. 2 index bars with only points and 1 index bar with only intervals will produce edges.

3. Only intervals in all 3 bars will produce only volumes.

4. Intervals and points in the same bar will produce faces and/or volumes using the following algorithm:

a. Start with the i-index bar.
For every negative number, treat the other 2 bars as though there were no negative numbers, and produce all regions as a product of the intervals in those 2 bars. Each region becomes a face where the i-index is the absolute value of the i-index in the progression. Do this for each negative i-index.

b. Do the same for j-index bar instead of i.

c. Do the same for k-index bar instead of j.

d. Throw away all intervals in each of the 3 directions which have negative numbers. Treat what remains (if any) as a selection of volumes - i.e. products of intervals.

Examples

Index progressions will be demonstrated using the following simple multi-block part shown in **Figure 19**. The block part was created using the **block** command:

```
block
1 3 5 7 8 9; c i-index list
1 2 3 4 5; c - j-index list
1 3 4 6; c k-index list
1 2 3 4 5 6; c x-coordinates
1 2 3 4 5; c y-coordinates
1 2 3 4; c z-coordinates
```

This block part has 6 partitions in the i-direction, 5 partitions in the j-direction and 4 partitions in the k-directions. **Figure 19** shows the orientation of the i, j, and k index bars in the computational

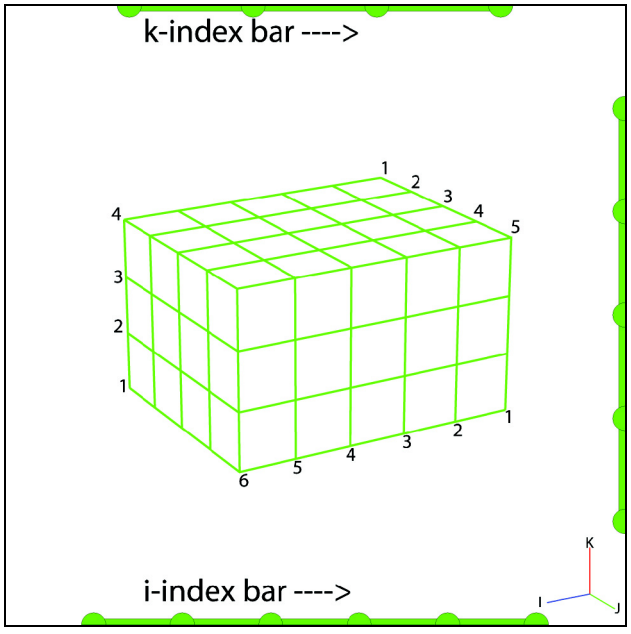


Figure 19 Block Part - Computation Window

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

window. The i, j, and k index bars are used for a selection of intervals and/or partitions. In the following examples, selected partitions and intervals are colored red along the index bars. Objects in the mesh will be highlighted.

Example 1 :

```
1 3 0 4 5; 2 3 0 4 5; 3 4;
```

is depicted in **Figure 20**.

The first index list defines 2 intervals in the i-direction: from 1 to 3 and from 4 to 5. The zero indicates the interval from 3 to 4 is to be skipped. **True*Grid*®** will use this set of two intervals, in combination with the intervals in the j and k directions, to form 3-dimensional regions. The second index list defines two intervals in the j-direction, from 2 to 3 and from 4 to 5. The third index list defines one interval in the k-direction. Solid regions are highlighted in cyan.

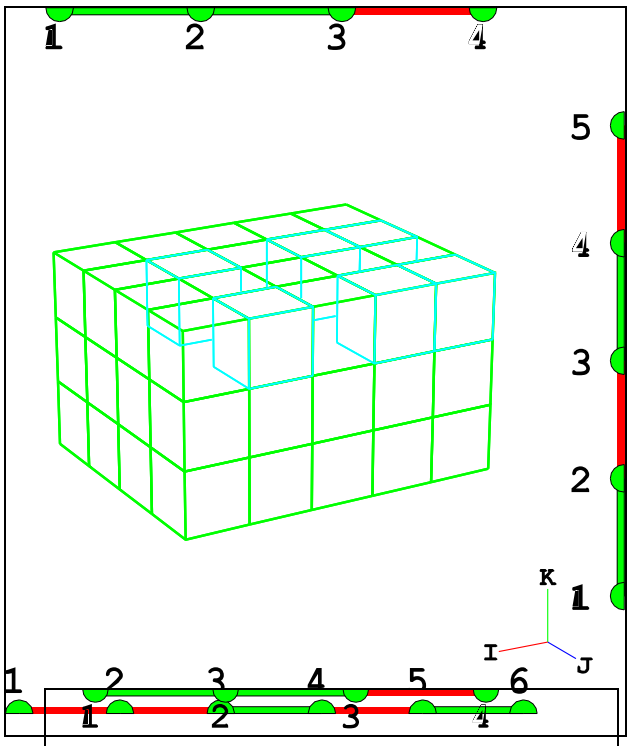


Figure 20 4 selected regions - volumes

True*Grid*® constructs a set of three dimensional regions from these index lists by selecting an interval from the first list to define the range in the i-direction, an interval from the second list to define the range in the j-direction, and an interval from the third list to define the range in the k-direction. It then produces all possible combinations of the intervals in the i, j and k-directions, respectively. Thus the index progression above is equivalent to the following 4 regions:

```
1 2 3 3 3 4     4 2 3 5 3 4     4 4
3 5 5 4     1 4 3 3 5 4
```

Example 2 is derived from Example 1 :

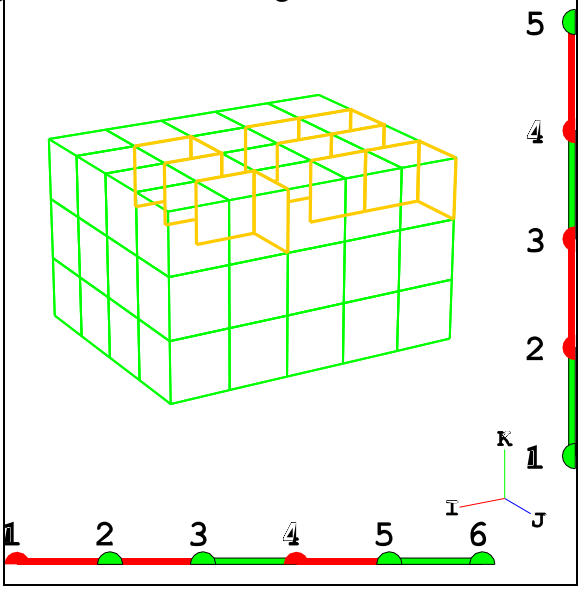


Figure 21 10 selected regions - faces

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
-1 3 0 -4 5;-2 -3 0 -4 5; 3 4;
```

In this example, faces are selected by specifying the negative reduced indices. This is equivalent to clicking on the corresponding nodes along the index bars at the ends of the selected interval (**Figure 21**). This is also equivalent to selecting the following 10 regions :

```
1 4 3 1 5 4    1 2 3 1 3 4
4 2 3 4 3 4    4 4 3 4 5 4
1 4 3 3 4 4    1 3 3 3 3 4
1 2 3 3 2 4    4 4 3 5 4 4
4 3 3 5 3 4    4 2 3 5 2 4
```

Example 3:

```
1 2; -2; -4;
```

In Example 3, edges are selected by specifying one interval and two negative reduced indices (**Figure 22**). The interval in the i-direction is from 1 to 2. The other two indices are j=-2 and k=-4.

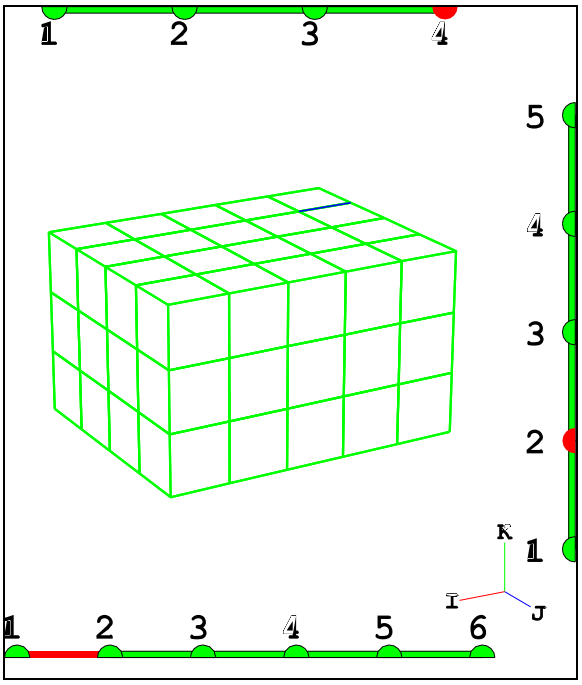


Figure 22 1 selected region - i-edge

So there is one selected edge:

```
1 2 2 2 4 4
```

The next two examples demonstrate selection of the edge in the j and k-direction, respectively.

Example 4 - the edge in the j-direction (**Figure 23**):

```
1 2; -2; -4;
```

The region notation of this edge is:

```
1 1 2 3 4 4
```

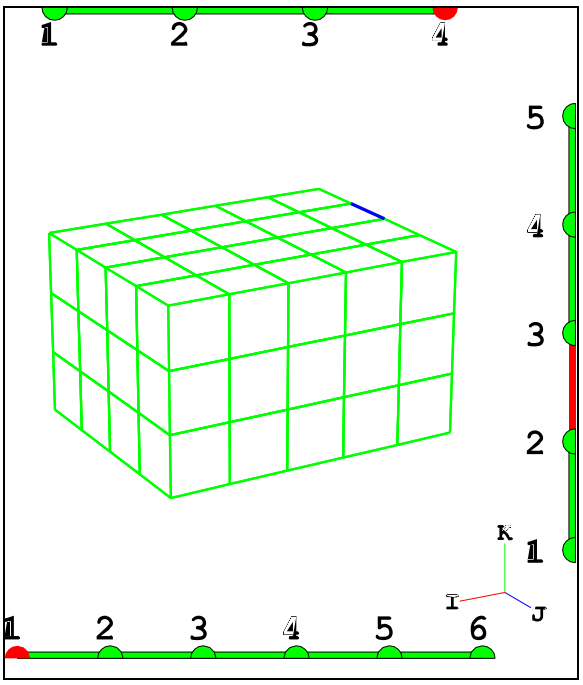


Figure 23 1 selected region - j-edge

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example 5 - an edge in the k-direction (**Figure 24**):

```
-1; -2; 3 4;
```

The region notation of this edge is:

```
1 1 2 2 3 4
```

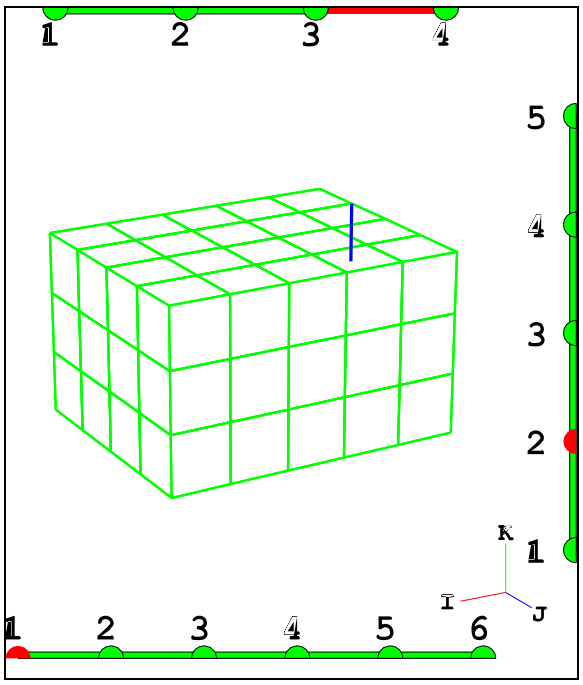


Figure 24 1 selected region - k-edge

Example 6 - more complicated selection of faces similar to Example 2 (**Figure 25**):

```
-1 3 0 -4 5;
-2 -3 0 -4 5;
-1 0 3 4;
```

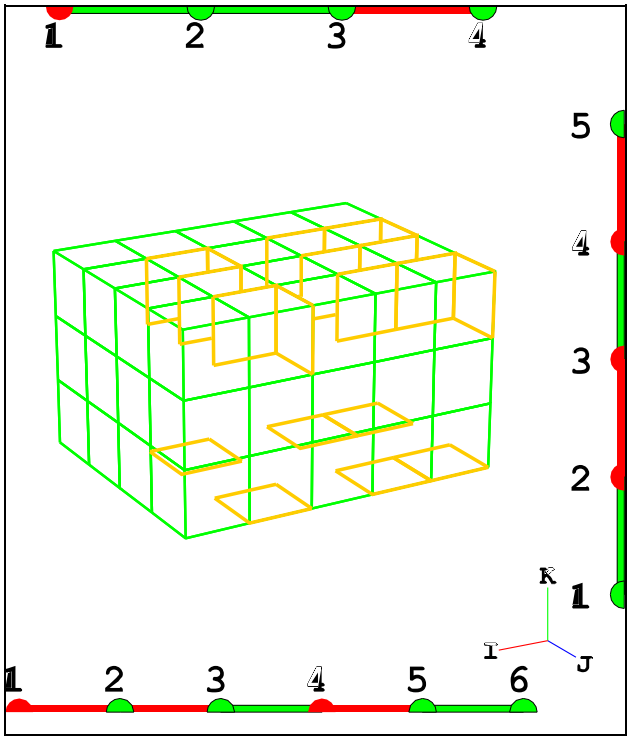


Figure 25 14 selected regions - faces

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example 7 - another more complicated selection of edges (**Figure 26**):

```
1 3 0 4 5; -2 -3 -4; -4;
```

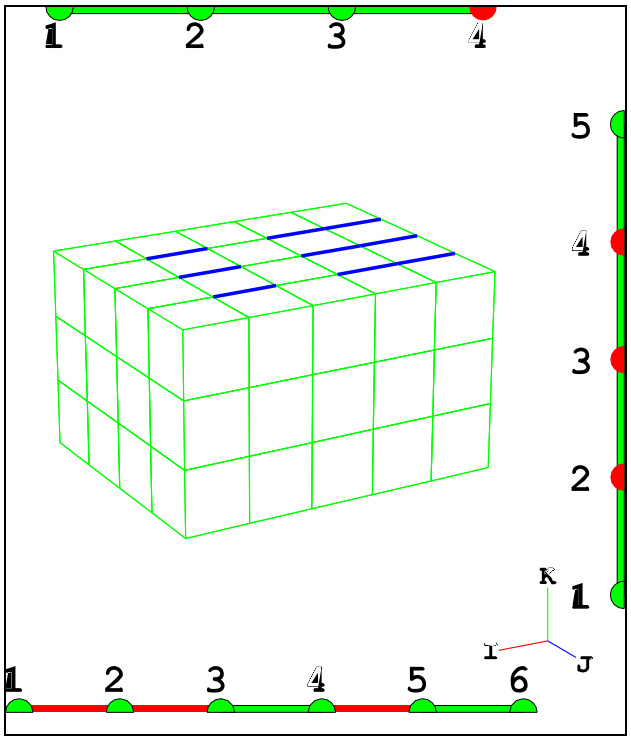


Figure 26 6 selected regions - edges

Example 8 - selection of faces forming 4 intersecting planes similar to Example 3 (**Figure 27**):

```
-1 -6; 1 -3 5; 1 -3 4;
```

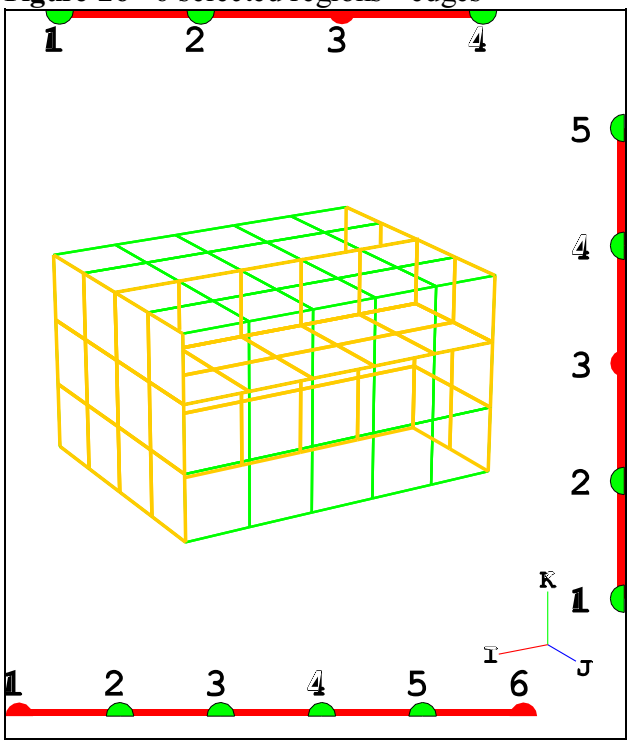


Figure 27 4 selected regions - faces

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

6. Conventions

The syntax for commands issued in batch mode are described in this manual were literals are highlighted in bold. Symbols to be substituted are italicized. Buttons in the GUI are bolded and italicized. Each **True*Grid*®** command is described by an entry like the following:

command summary description

command *arguments* brief description of functionality
with brief descriptions of what the *arguments* should be. Three standard arguments are:

vertex	is a node described by its reduced indices *i j k*
region	is a region described by the minimum and maximum reduced indices, $i_{min}\ j_{min}\ k_{min}\ i_{max} j_{max}\ k_{max}$
progression	is an index progression of the form $i_1\ i_2 \ldots i_m\ ;\ j_1\ j_2 \ldots j_n\ ;\ k_1\ k_2 \ldots k_p\ ;$

Remarks

When present, the Remarks section describes the command in even greater detail. It may describe the context in which the command is normally used, and other commands used in association with this command. It may describe side effects. It may describe other, similar commands. In many cases, it includes a description of where to find the command in the menus.

Algorithm

When present, this section describes the algorithms with which **True*Grid*®** implements the command.

Examples

When present, the Examples section will give an example of the usage of the command, usually showing how it is used with other commands. Occasionally there may be a complete illustrated example of the construction of a simple model, in which this command plays a critical role. The exact text for these examples are in Courier font. The keyword commands are also bolded.

7. Running True*Grid*®

This section describes in general how you run **True*Grid*®**. After reading it, you will have a good understanding of the general sequence of actions you and **True*Grid*®** will perform in order to generate your meshes.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Execution Environment

Before running **True*Grid*®**, you or your system administrator should set up the **True*Grid*®** execution environment. Setting up this environment primarily involves installing the **True*Grid*®** executable and support files for the graphical user interface and optionally setting some environment variables including the path to tg.exe. See the Installation Instructions for **True*Grid*®'** for a complete description:

Install_WIN.txt or Install_WIN.pdf for WINDOWS operating systems

Install_LINUX.txt or Install_LINUX.pdf for the REDHAT LINUX operating systems

Two Modes and Two Input Channels

Once you have set up the execution environment, you are ready to run **True*Grid*®**. On UNIX, LINUX, and OS-x systems, type tg in any window to run **True*Grid*®**. There are several ways to run **True*Grid*®** in a WINDOWS system on a PC.

(i) click on START, PROGRAMS, the XYZ program group, and **True*Grid*®**
(ii) click on the TG shortcut on the desktop (you must set up the shortcut)
(iii) type tg in a Command Prompt Window
(iv) click on a **True*Grid*®** command input file ending with ".tg"

The last option requires that you set a flag in TGControls so that the system knows to run **True*Grid*®** with files ending with ".tg".

True*Grid*® can be run in two modes, with and without the Graphical User Interface. The Graphical User Interface (GUI) has menus, graphical displays of the mesh, a text window, and mouse control of the picture. The GUI is active by default. One can deactivate the GUI by issuing the **g=nogui** option on the execute line when running **True*Grid*®** from a window. The prompts for commands will appear in that window. Use a Command Prompt window when running **True*Grid*®** in nogui mode in WINDOWS on a PC.

There are two ways to enter commands into **True*Grid*®** for execution, interactive and batch. The easiest thing to do is to enter commands interactively (clicking on buttons or typing commands) by not selecting a command input file. If **True*Grid*®** commands in a text file are to be executed, then use batch input by including the option **i=***cmd_f* on the execute line, where *cmd_f* is the name of the text file. This batch file can be also executed in **True*Grid*®** by issuing the **include** command either from another batch file or interactively.

Alternatively, when running in WINDOWS on a PC, a folder of files will be displayed when

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

TrueGrid® is run. Use the browser if the file you wish to run is not found in the default folder. Click on the desired file and click on open. Click on cancel if there is no command input file.. Run the utility TGControls to choose the default folder.

A single session with **TrueGrid®** can be a combination of batch and interactive input. The **interrupt** and **resume** commands can be used to switch **TrueGrid®** between batch and interactive input. To accomplish this, insert **interrupt** commands into the command file, before starting **TrueGrid®**, at the points where you want to switch from batch to interactive mode. Then start this batch and interactive session with **TrueGrid®** by selecting the command input file for execution. **TrueGrid®** will execute commands from the command input file until it reaches one of the interrupts, which causes **TrueGrid®** to switch to receiving input interactively. When **TrueGrid®** is receiving input interactively, you can issue the **resume** command (click on the **RESUME** button or type resume) to resume execution of the commands from the command input file.

The typical **TrueGrid®** session is with interactive input and with the Graphical User Interface.

Command Line

You can run **TrueGrid®** from a command prompt window. The syntax for WINDOWS is:

tg [**i**=*cmd_f*] [**s**=*rerun_f*] [**o**=*output_f*] [**g=nogui**] [**-font**]

The syntax for UNIX, LINUX, and OS-x is:

tg [**i**=*cmd_f*] [**s**=*rerun_f*] [**o**=*output_f*] [***g=nogui***] [**len**=*size*] [**-font** *fontname*] [**-display** *display*]

The nogui option can also be gotten using **-nogui** on the execute line.

Alternatively, you can get key information from **TrueGrid®**.

tg -v	returns the version number
tg -h	returns the list of command line options
tg -lic	returns the path to the .tgauth file

The **TrueGrid®** WINDOWS distribution includes 4 executables. In all cases, a small window pops up first when you execute it with version information.

tg: TRUEGRID VERSION 3.1.4 (32 bit, openGL graphics) DATE 1/27/17
tgw: TRUEGRID VERSION 3.1.4 (32 bit, Native WINDOWS graphics) DATE 1/27/17
tgd: TRUEGRID VERSION 3.1.4 (64 bit, openGL graphics) DATE 1/27/17

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

tgdw: TRUEGRID VERSION 3.1.4 (64 bit, Native WINDOWS graphics) DATE 1/27/17

The **True*Grid*®** LINUX 32bit distribution includes 2 executables. In both cases, a small window pops up first when you execute it with version information.

tg: TRUEGRID VERSION 3.1.4 (32 bit, openGL graphics) DATE 1/27/17
tgx: TRUEGRID VERSION 3.1.4 (32 bit, X-windows graphics) DATE 1/27/17

The **True*Grid*®** LINUX 64bit distribution includes 2 executables. In both cases, a small window pops up first when you execute it with version information.
tgd: TRUEGRID VERSION 3.1.4 (64 bit, openGL graphics) DATE 1/27/17
tgdx: TRUEGRID VERSION 3.1.4 (64 bit, X-windows graphics) DATE 1/27/17

Command Input File

Using the option **i=***cmd_f* causes **True*Grid*®** to execute the commands found in the file named *cmd_f*. If there are no **interrupt** commands in the file, then **True*Grid*®** executes all of the commands in the file. When the end of the file is reached, **True*Grid*®** switches the input to interactive. If there is an **interrupt** command in the file, then **True*Grid*®** executes all commands prior to the first **interrupt** command and switches input to interactive.

If you do not invoke this option, then **True*Grid*®** will receive commands interactively.

Session/Rerun and History Table File

True*Grid*® always saves your work by writing commands to a file. If you invoke the option **s=***rerun_f*, then **True*Grid*®** uses the file name that you provide to save all commands needed to reproduce the mesh. This file will also contain any error or warning messages. Otherwise, **True*Grid*®** will use the file named tsave. After your **True*Grid*®** session, you can rename the file and submit it as a command input file for another session. You can modify the mesh by modifying this file and rerunning it as a batch file.

As a safety precaution, if there already exists a file by the name tsave, it will be renamed "tsave#". If there already exists a file named tsave#, it will be renamed tsave##. You have two chances to rename or permanently save what is found in the session file before it is deleted.

Each time you build a **block** or **cylinder** part, the corresponding history table is written to the file named tghist. For example, suppose the following commands were issued to **True*Grid*®**:

```
block 1 3;1 3;-1;0 2 0 2 0
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
insprt 1 2 1 1
insprt 1 4 1 1
mseq i 4 4 mseq j 4 4
dei 2 3; 2 3; -1;
pb 3 2 1 3 2 1 y 2.000000e+00
pb 2 2 1 2 2 1 xy 6.720001e-01 6.720001e-01
undo
pb 2 3 1 2 3 1 x 2.000000e+00
sd 1 cy 0 0 0 0 0 1 2
sfi 1 2; -3; -1; sd 1
sfi -3; 1 2; -1; sd 1
pb 2 2 1 2 2 1 xy 8.000000e-01 8.000000e-01
```

Then the tghist file will contain the following lines, as a result:

```
block
1 6 11 ;
1 6 11 ;
-1 ;
0.0 1.0 2.0
0.0 1.0 2.0
0.0
```

CMD	Region/Progressio	Arguments	CMD#	Act/Deact
pb	2 1 1 2 1 1	xyz 1.0 0.0 0.0	c 3	active
pb	2 3 1 2 3 1	xyz 1.0 2.0 0.0	c 4	active
pb	1 2 1 1 2 1	xyz 0.0 1.0 0.0	c 6	active
pb	2 2 1 2 2 1	xyz 1.0 1.0 0.0	c 7	active
pb	3 2 1 3 2 1	xyz 2.0 1.0 0.0	c 8	active
dei	2 3; 2 3; -1 1;		c 9	active
pb	3 2 1 3 2 1	y 2.0	c 10	active
pb	2 2 1 2 2 1	xy 0.67200011 0.67200011	c 11	deactivated
pb	2 3 1 2 3 1	x 2.0	c 12	active
sfi	1 2; -3; -1;	sd 1	c 13	active
sfi	-3; 1 2; -1;	sd 1	c 14	active
pb	2 2 1 2 2 1	xy 0.80000001 0.80000001	c 15	active

The revised **block** command at the top of this table and the associated command history table is designed to aid in cleaning up the session file (tsave) and in better understanding complex input to a part. Notice the following features in this table:

i. The insert partition commands (**insprt**) have been removed. The **block** command has been changed to reflect the partitions that were added. All of the subsequent commands have their reduced indices modified to reflect the inserted partitions. In addition, **pb** commands were added, one for each new vertex along the new partitions.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ii. The change in the number of elements in each **block** (the **mseq** commands) have been replaced by changing the full indices in the **block** command.

iii. The column on the right indicates which commands have been deactivated.

One way to take advantage of this file is to remove a few lines, including the lines with deactivated commands, one can have a new clean version of the commands that form the part. Take care in doing this because this table does not contain any of the geometry commands that may have been issued when the part was formed. Using this table will require some text editing of you session file (tsave).

If you have built a large complex part with numerous insert partition commands, you probably have noticed that it takes longer to rerun. Inserting partitions is a costly feature. Before a partition is inserted, **True*Grid*®** has to rebuild the part. If you substitute the commands from this history table, it will rerun more efficiently.

Mesh Output File

Use the **o**=*output_file* to name the file generated by **True*Grid*®** as the input for the simulation code specified by you during your **True*Grid*®** session. This file contains a description of the mesh and all other parameters you have specified, formatted specifically for that simulation code. If you do not invoke this option, then **True*Grid*®** names the file ``trugrdo``. This file is written only when:

(i) an output option, such as **nastran**, has been issued
(ii) the **merge** phase has been entered
(iii) the **write** command has been issued

It is assumed, by this, that other commands have been issued to generate a mesh, material properties, conditions, options, and element properties before the **write** command is issued.

No Graphics Option

The option **g=nogui** causes **True*Grid*®** to run without graphics, displaying windows, and menus. Prompts for input appear in the window in which **True*Grid*®** was run.

Workspace

On UNIX, LINUX, and OS-x systems, the option **len**=*size* allows you to specify the initial memory size, in megabytes, which **True*Grid*®** will use. The default is 20 which is sufficient for many problems. **True*Grid*®** will get additional memory, if possible, when the initial amount has been usedd. On WINDOWS systems, use the TGControls window to set the limit on memory for workspace. You will

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

have system limitations to consider. It is advisable that you keep the amount of workspace plus the size of **True*Grid*®** below the amount of RAM on your system, or the performance will degrade. If the number of nodes in your parts are relatively small compared to the total number of nodes in the model, then you can expect to use about 120 bytes of workspace per node on a 32 bit version of **True*Grid*®** (twice that for a 64 bit version of **True*Grid*®**). If the parts are relatively large, double the nodal workspace estimate. About 2 megabytes are needed for graphics and will increase as the resolution (see the **reso** command) is increased. Workspace is also needed for geometry. In particular, IGES trimmed surfaces require a lot of memory. A simple estimate is to double the size of the IGES file for the amount of memory needed by **True*Grid*®** (double it again for a 64 bit version of **True*Grid*®**).

Font

In the X Window System used by UNIX, LINUX, and OS-x, the **-font** *fontname* option lets you choose the font with which **True*Grid*®** will display text. This option adheres to the X standard and passes this data to the windowing system. Use the **xlsfonts** utility to get a list of fonts available on your machine. It is best to choose a fixed width font (that is, not proportionally spaced). It is safest to quote the font name to protect it from misinterpretation by the shell because many of the font names have special characters. By default, **True*Grid*®** uses the 9x15 bold font if available, and 9x15 otherwise. You can change the default font with the TGFONT environment variable.

On a PC running WINDOWS, you can specify the font by running **True*Grid*®** from a Command Prompt window using the **-font** option. First, the browser window to select on command input file will appear. After you select a file or cancel, the font browser will pop up so that you can select from the list of available fonts. If you wish to change the default font, run the TGControls window and click on ***Font***.

Display

The option **-display** *display* has the usual meaning in the X Window System used by UNIX, LINUX, and OS-x - it chooses the display. This option adheres to the X standard and passes this data to the windowing system. In some cases you might have to quote the *display* argument to protect it from the shell. For example, one might type:

tg -display "mercury:0.0"

where mercury is the machine name that owns the display monitor. You may have to run **xhost** for permissions.

You also can specify the display with the TGDISPLAY environment variable.

There is no equivalent feature for a PC running WINDOWS.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Mesh Generation

The **True*Grid*®** mesh generation process is divided into three phases: Control, Part, and Merge. You issue commands to enter and exit these phases. In the Control Phase, some of the tasks that you can perform are: define surfaces and curves, read surface and curve data from a CAD/CAM IGES file, select the simulation code for which an input file is to be generated, set simulation code-specific options and element and material properties, define global part replications and transformations, and set global loads and conditions.

You can then issue a command to initialize a new part, thereby exiting the Control Phase and entering the Part Phase. In this phase, you construct the mesh for a part by performing geometric and topological operations. You can use the surfaces and curves defined or acquired in the Control Phase, and you can also define and use additional surfaces and curves in this phase. You can also assign sets, conditions, constraints, loads, properties, diagnostics, transformations, and replications to the part.

After issuing a command to end the part, you can initialize another part, re-enter the Control Phase, or enter the Merge Phase. In the Merge Phase, **True*Grid*®** can merge the coincident nodes of different parts. You can set the tolerances for this merging operation. You can also display your complete model including surfaces, curves, parts, diagnostics, materials, conditions, loads, and constraints. It is in this phase that you direct **True*Grid*®** to write the simulation code input file by issuing the **write** command.

Termination

To end your session, you enter the **end** or **exit** command in the text window or left-click the **EXIT** button in the Menu window. There may be times when you launch some massive batch calculation within **True*Grid*®** and then decide that you don't want it to complete. The standard ways of killing a process on the PC and on UNIX/LINUX platforms will work here as well. On a UNIX, LINUX, or OS-x machine, you can identify the process id (PID) by using the ps(1) command and then you can "kill" that process. On a PC running WINDOWS, you can use Ctrl-Alt-Delete to bring up the Task Manager and halt **True*Grid*®**. You can also pop forward the background **True*Grid*®** window and kill **True*Grid*®** with Ctrl-c.

CAD/IGES Geometry

Many users wish to use CAD (Computer Aided Design) geometry from ProE, CATIA, or SolidWorks, to name a few. This can be done through the IGES (Initial Graphics Exchange System) standard file format. There are usually several forms of geometry that can be exported by these CAD systems. Be sure to choose trimmed surfaces for use in **True*Grid*®**. The **iges** command is used to read in the IGES file. Check either its on-line or written documentation for the syntax and a list of the geometrical features which it supports. There is also an example in the Examples Manual which demonstrates

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

meshing IGES geometry.

Alternatively, you can generate geometry within **True*Grid*®**. However, **True*Grid*®** does not match the feature rich geometric capabilities found in some of the large CAD systems mentioned above. On the other hand, CAD systems usually generate many surfaces that are far from ideal for meshing purposes. These surfaces tend to have small gaps between them or overlap each other. These problems are easily handled in **True*Grid*®**. The **sd** command with the easy to use **sds** option combines many surfaces into one without changing any shapes. The projection method automatically handles gaps and overlaps. There is no need to heal or fix the CAD geometry for **True*Grid*®** use. When building a mesh, there is no distinction between CAD geometry and geometry created within **True*Grid*®**.

File and Path Names With Spaces

There are numerous commands that either read or write a file and require both a path and file name. The most convenient way is to set the path name to all files using the **True*Grid*®** Controls utility to name the working directory. Alternatively, the path can be specified relative to the working directory or from the device name in WINDOWS or the root in LINUX. If there is any spaces in the path or the file name, the entire string that identifies the path and fille name must be double quoted. For example:

".\subfolder name\file name" or "c:\TG examples\big plane.tg" for WINDOWS

"./subfolder name/file name" or "/usr/TG examples/big plane.tg" for LINUX

Commands that require a path and a file name include: **iges**, **mof**, **include**, **vpsd**, **stlsd**, **sd**, **readmesh**, **edgefile**, **useiges**, **saveiges**, **wiges**, **wrsd**, and **postscript**. You may also need this form when specifying the command input file if you are running from a command prompt window in WINDOWS or executing **True*Grid*®** from a working directory in LINUX. You will also need the double quotes when defining the TGHOME environment variable, if there is a space in its path name.

Miscellaneous

There is no limit on the length of a command line you type during an interactive **True*Grid*®** session. But batch input files have a maximum line length of 256 characters. This is not a serious restriction because **True*Grid*®** generally ignores line breaks. Therefore you can spread a command over several lines or stack several commands in one line, without doing anything special. There are a few exceptions:

The title line, comments, and similar text end with the end of a line.

A Fortran-like expression ends with the end of the line, unless the line's last character

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

is "&". In that case, it continues to the next line.

When writing batch files, it helps to use comments liberally. **True*Grid*®** will ignore anything in a line that follows a "c" or "$" word (that is, a "c" or "$" separated by spaces from any other character in the line.) It will also ignore any group of lines that are surrounded by { and }.

There are many commands with an arbitrarily long list of parameters. A semi-colon is used to signify the end of the list of parameters. When you use the dialogues to select options and list parameters, the insertion of the semi-colon is done automatically. When you execute the filled in dialogue, you will notice that the command is printed in the text window with the semi-colons inserted. If you choose to type the commands into the text window or build a command file from scratch, you can use the semi-colon liberally to be safe, since any unneeded semi-colons will be ignored.

All numbers must either be zero or else have magnitude approximately between 10^{-18} and 10^{18}. This is to prevent problems with underflow and overflow conditions. If the number is to be interpreted as an integer, then its magnitude must not exceed approximately 10^{9}.

Typing **help** *command* for a **True*Grid*®** command will not only open a help box explaining the syntax, but the window's title will tell you which sub-menu the command is under.

Typing **dial** *command* will open the dialog box for that command without having to click through the GUI. Notice that this can be very helpful when you know the name of the command but do not know which sub-menu it is located under.

Phases

True*Grid*® begins in the Control Phase. When you issue the **block**, **cylinder**, or **blude** command, it changes to the Part Phase. An **endpart** or **control** command ends the present part and puts it back in the Control Phase. A new **block**, **cylinder**, or **blude** command ends the present part and starts a new one. The **merge** command ends the present part and puts it in the Merge Phase. Once you enter the **endpart**, **control**, **block**, **cylinder**, **blude**, or **merge** command, you may not go back to the previous part to make changes.

True*Grid*®'s graphical user interface has several ways to show you which phase **True*Grid*®** is in:

1. the prompt in the text window,
2. the title bar of the text window,
3. the windows that are open,
4. the menu system and help packages.

In the Control Phase, only the text window is open. There is no computational or physical mesh because

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

this phase is nearly obsolete and no effort has been invested to improve it.

In the Part Phase, all windows are open or available.

In the Merge Phase, the computational window is no longer available. All other windows are open or available.

True*Grid*® changes the main menus and submenus when it transitions from one phase to another. These changes reflect the fact that different commands are available in different phases.

Basic Interactive Session

The following outline of an interactive session shows you some of the basic mesh generation tasks you might perform in each of the mesh generation phases.

This example is specific to DYNA3D and there are some features in this example which are unique to dynamic analysis or specific to DYNA3D. This example can be easily adapted to form the input to most simulation codes.

It is assumed that you are familiar with the control of the graphics and the use of both the Computational window and the related use of the **F1**/**F2** function keys.

In this example, **True*Grid*®** is started from a command line. If you are running from a WINDOWS system, start **True*Grid*®** using one of the methods described above. Remember to change the name of the saved session file from tsave to some other name after you complete you **True*Grid*®** session.

Initiation

```
tg s=mysave o=mysim
```

Global Properties

The **True*Grid*®** graphical user interface is initialized and the Text/Menu window is displayed. You are now in the Control Phase.

Use the ***OUTPUT*** main menu to select the output option, such as DYNA3D, as the simulation code for which an input file will be generated.

Set the time step and other analysis options by using the ***ANALYSIS*** menu and ***DYNAOPTS*** dialogue.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Set material and element properties for each numbered material using the ***MATERIAL*** menu and ***DYNAMATS*** dialogue.

Set the default initial velocity by using the ***VEL/ACC*** menu and ***VELOCITY*** dialogue.

Set the properties on a numbered contact surface using the ***INTERFACE*** menu and ***SID*** dialogue.

Define a numbered load curve using the ***2D CURVE*** menu and ***LCD*** dialogue.

Geometry

Change to the Merge Phase to inspect the geometry to be generated by using the ***MERGING*** menu and ***MERGE*** dialogue. The Text/Menu, Physical, and Environment windows are displayed.

Import an IGES file by using the ***CAD*** menu and ***IGES*** dialogue.

Also, surfaces can be formed by using the ***SURFACE*** menu and ***SD*** dialogue.

Curves can be formed using the ***3D CURVES*** menu and ***CURD*** dialogue.

The easiest and most versatile 3D curve is a spline. Use the ***3D CURVES*** menu and ***SPLINE*** to get the Point List dialogue. Select z-buffer type of graphics using ***HIDE*** or ***FILL*** in the Environment window. Then select ***DRAW*** in the Environment window to redraw the picture in the Physical window. Select the ***PICK*** panel and ***Z-BUFFER*** in the Environment window to pick control points from the picture. Use the left mouse button to select points from the Physical window. When complete, select the ***Save*** button in the Point List dialogue, fill in the curve number and ***Accept***. Then ***Quit*** the Point List dialogue.

Mesh

Initialize a new part's geometry and topology by using the ***PARTS*** menu and ***BLOCK*** dialogue. You are now in the Block Phase. The Text/Menu, Computational, Physical, and Environment windows are displayed on your screen. You are now in the Part phase.

Delete any unwanted regions from the block structure of the part using the ***MESH*** menu and ***DE*** or ***DEI*** dialogue. Alternatively, select a region in the Computational window with the left mouse button and click on the ***DELETE*** button in the Environment window.

Pre-position the vertices of the mesh using the MESH menu and any of the dialogues ***PB***, ***MB***,

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

MBI, ***TR***, or ***TRI***. There are many other more convenient ways to move these control points of the mesh but are not appropriate for this short discussion.

Select regions of the mesh in the Computational window. Project these regions of the mesh onto the surfaces using the ***MESH*** menu and ***SF*** or ***SFI*** dialogue. Alternatively, use the ***LABELS*** tab and the ***SURFACES*** button in the Environment window to label the surfaces in the picture. Then select the ***PICK*** tab and the ***LABEL*** button so that you can pick a surface in the picture by its label. Move the mouse into the Physical window and select the appropriate surface by clicking on its label. Then use the ***PROJECT*** button in the Environment window to project the selected region of the mesh to the selected surface. This latter method is the preferred method because it is more efficient. This is repeated as needed to deform the mesh to the required shape.

Set the part's initial velocity, if different from the default, using the ***DIS/VEL/ACC*** menu and ***VELOCITY*** dialogue.

Set nodal constraints using the ***BOUNDARY*** menu and ***B*** or ***BI*** dialogue.

Assign faces or nodes to a numbered contact surface using the ***INTERFACE*** menu and ***SI*** or ***SII*** dialogue.

Impose a pressure load controlled by a numbered load curve using the ***FORCE*** menu and ***PR*** or ***PRI*** dialogue.

Set the default material for all regions of the part by using the ***MATERIAL*** menu and the ***MATE*** dialogue. Regions requiring a different material are set with the ***MT*** or ***MTI*** dialogue.

End the part by using the ***PARTS*** menu and ***ENDPART*** dialogue. You are now in the Control Phase. Only the Text/Menu window is displayed. Repeat the creation of a mesh part as often as needed.

Assemble and Verify

Use the ***MERGING*** menu and ***MERGE*** dialogue to enter the Merge Phase. The Text/Menu, Physical, and Environment windows are displayed.

Display a measure of the orthogonality of the mesh by using the ***DIAGNOSTIC*** menu and ***MEASURE*** dialogue.

Set the tolerance and merge coincident nodes by using the ***MERGING*** menu and ***STP*** dialogue.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Display loads, constraints, and conditions using the ***GRAPHICS*** menu and ***CONDITIONS*** dialogue.

Write the input file for DYNA3D by using the ***OUTPUT*** menu and ***WRITE*** dialogue.

End your **True*Grid*®** session by clicking on the ***EXIT*** button.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

II. Graphical User Interface

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

1. TrueGrid Windows

The following windows are used throughout a **True*Grid*®** session.

Text/Menu This window has two subwindows, one for text and one for menus. You have the option to issue commands by typing in the text subwindow. You also have the option to issue commands from a command dialogue box. The mouse need not be in this window for its input line to be active. In fact, your typing will be entered into this window as long as the mouse is in any **True*Grid*®** window other than a dialogue box. The menu subwindow gives you convenient access to the on-line help and to command dialogue boxes.

Environment You use the mouse in this window to issue frequently issued commands such as rotation, translation, zoom, displayed items, attach, project etc.

Computational This is where you view the computational mesh. You can use the mouse to select regions and index progressions for use in commands.

Physical This is where you view the actual physical mesh. You also can use the mouse to modify the mesh.

History This is an interactive command table that aids you in debugging the mesh. It is available only in the part phase.

2D Curves This window is used to display 2D curves. It is activated by using the **lv**, **lvi**, **lvc**, or **lcv** commands.

Dialogue When you click on a menu item in the main menu of the Text/Menu window and then click on a command on the subsequent submenu, a dialogue window (sometimes referred to as a dialogue box) is created. You can also get a dialogue window for a command by typing **dial** *cmd* where *cmd* is the keyword for a command.

Help A help window is created whenever you request help on a command or a command category. You can also type **help** *cmd* to get the help window for a command where *cmd* is the keyword for a command.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

True*Grid*®'s complete screen with Text/Menu, Computational, Physical and Environment windows:

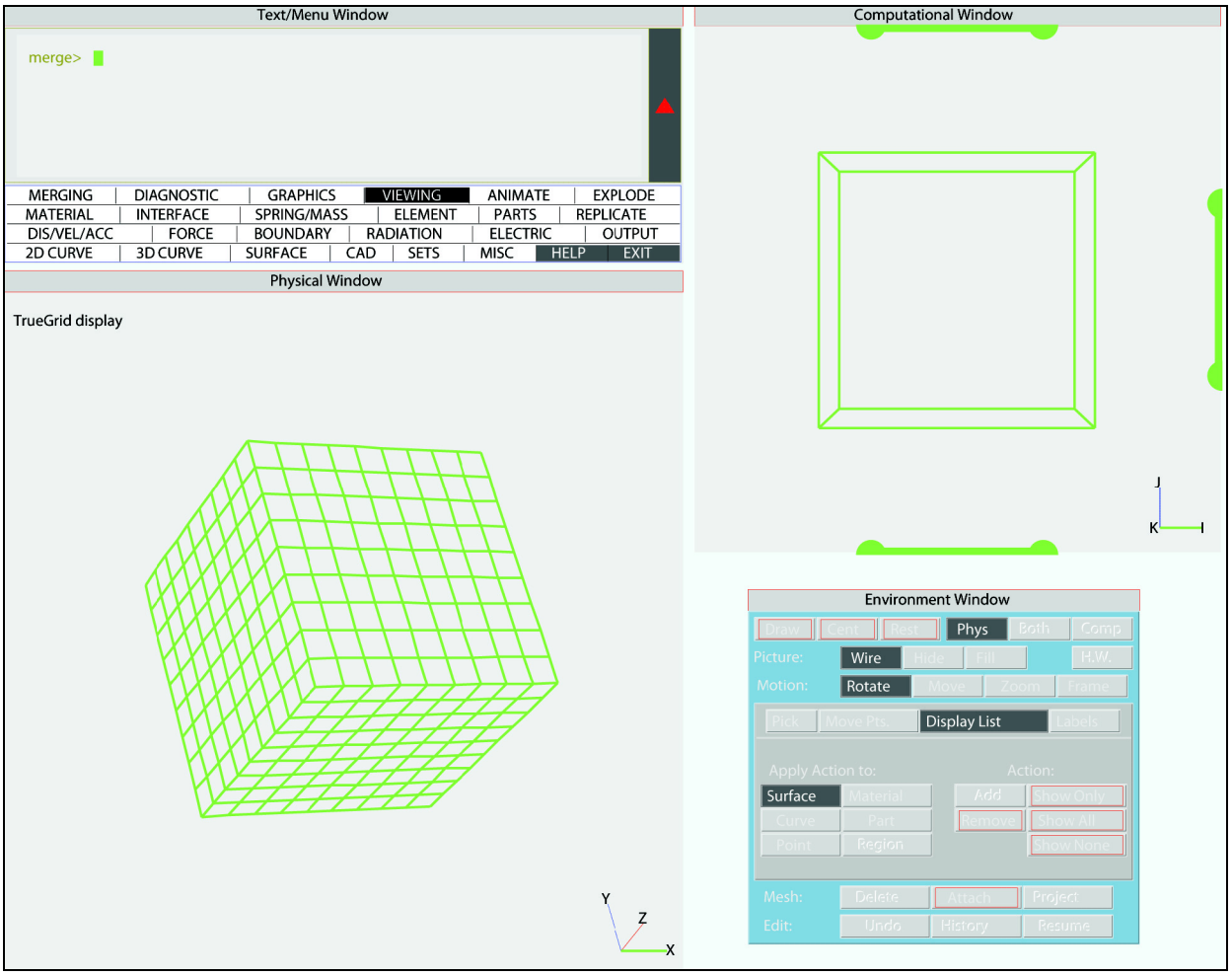


Figure 28 Complete Screen

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

2. The Text/Menu Window

The menus and text window save the same purpose, the selection of functions. They are combined to save space on the screen.

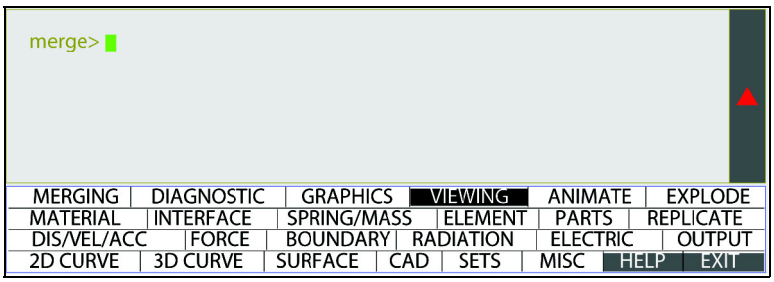


Figure 29 Text/Menu Window

Menu Window

The main menu for **True*Grid*®** normally resides at the bottom of the Text/Menu Window (**Figure 29**). Each menu item is a category of commands, except for the last two. These last two menu items have a grey background and are labeled ***HELP*** and ***EXIT***.

Left-clicking your mouse on the ***EXIT*** button does the same as typing an **end** command on the command line – **True*Grid*®** terminates. Upon ending, **True*Grid*®** displays the message

n o r m a l t e r m i n a t i o n

in the window initially used to invoke **True*Grid*®**. This message means that all files were properly closed and that resources used by the graphical user interface were properly freed.

When you select an entry from the main menu (if the ***HELP*** button is off), you will be selecting a submenu which replaces the main menu. The submenu contains a list of all the commands within the selected category of the main menu. The first rectangle of the submenu is highlighted in light red and is the name of the command category which you chose from the main menu. The last two rectangular areas are the ***HELP*** button and a ***MAIN MENU*** button. The latter of these will return you to the main menu. When you return to the main menu, **True*Grid*®** will automatically position the mouse over the category which you had previously chosen.

When you are in a submenu and left-click to select a command (with the ***help*** button off), **True*Grid*®** will create a *dialogue box* for that command. This window lets you specify any of the command's options or arguments, as discussed later in this chapter. There are two ways to dismiss a dialogue box

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

without invoking the function of the dialogue window. You can left-click your mouse on the ***EXIT*** button of this box, and then confirm with a ***yes***. Or you can type Control-Q, with the mouse anywhere within the dialogue box window.

When you are in a submenu and middle-click on a command (with the ***HELP*** button off), **True*Grid*®** will create a dialogue box, as appropriate, unless the command has no arguments, in which case **True*Grid*®** will execute the command immediately. Left-clicking on a command will always result in a dialogue box.

In either the main menu or a submenu, you can get help simply by left-clicking your mouse on the ***HELP*** button and then left-clicking again on a command button. Pressing the ***HELP*** button will toggle it on and off. While the ***HELP*** button is on, pressing any button (other than ***EXIT*** or ***MAIN MENU***) will create a help window for that button. When the main menu is active, the help window will contain a list of all the commands in the selected category. The command names are highlighted in yellow, and every command name is followed by a brief description of the command and its options. When a submenu is active, the help window will contain a description of the selected command (in black lettering on a white background) along with a full description of the command's syntax (in white lettering on a black background). **True*Grid*®** will destroy the help window when you toggle the ***HELP*** button off or when you click on ***EXIT*** or ***MAIN MENU***. Finally, the help window's title bar displays the name of the sub-menu under which the command is found. Thus, typing **help** *cmd* can be used to learn where the command *cmd* is found within the sub-menus.

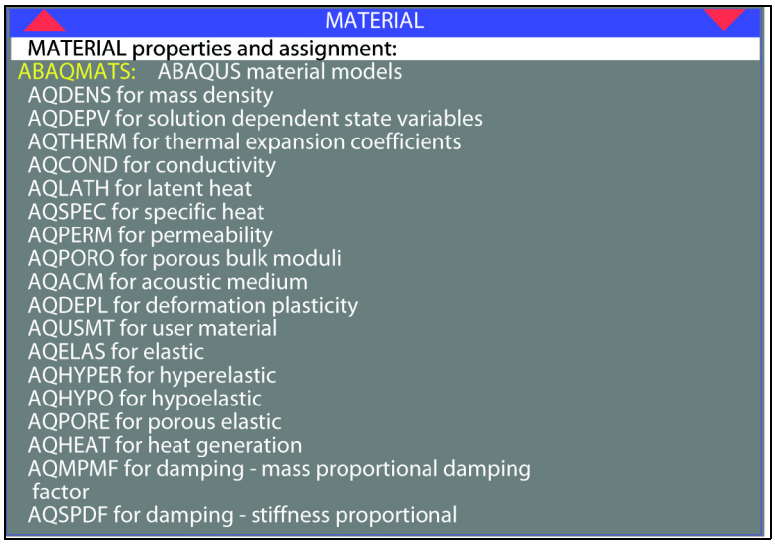


Figure 30 Help Window

If all of the text does not fit into a given window, then you can scroll up or down in the Text Window, Help Window, or Dialogue Boxes with the Page Up, Page Down, and arrow keys. These windows also have up- and down- arrows on the screen (for the text window, these arrows appear only in "scroll mode"; see page 74). A left mouse click on an arrow will scroll the window by a page, and a middle mouse click will scroll it by a line.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Text Window

You can enter commands in the upper portion of the Text/Menu window, and **True*Grid*®** will use it to display messages and prompts.

The text display has two modes: *normal* mode and *scroll* mode. Initially, the window opens in normal mode. In order to enable scroll mode, move your mouse to the up-arrow at the right side of the Text/Menu Window. The up arrow will turn green. Click the Left Mouse Button to enable scroll mode. You can disable scrolling (thus returning to normal mode) by either:

(1) pressing the Left Mouse Button while the mouse is in the text area
or
(2) hitting **Return/Enter** key on an empty command line

True*Grid*® automatically switches from normal to scroll mode in order to print text output.

When you enter a command into the text window, the cursor will move to the far left part of the command line until **True*Grid*®** has finished executing your command. Then it will return a prompt and put the cursor just after the prompt. You can issue multiple commands on one line if you like. Most commands need only be separated by a space, but you also can separate them by semicolons. There is no practical limit to the length of a line; the maximum length of a line is set by the length of the text buffer which is about 80,000 characters! You can even backspace across lines. However, you should remember that when **True*Grid*®** finds an error in one command on a line, it ignores all following commands that are on the same line.

The last line of text always remains stationary during scrolling.

You can grab any text and put it in the command line. Press the Left Mouse Button down while over the first character of the text string you want to grab. While holding the mouse button down, drag the mouse to the position of the last character of your text string. When you release the button, the text is saved in a buffer. Now, move the Mouse Pointer to the command line. Click the Middle Mouse Button to enter the text into the command line. The characters between the beginning and ending positions will be put on the command line. You cannot grab prompts; **True*Grid*®** will ignore them. If you grab across distinct lines, a new line feed will be issued in the command line. To reissue a number of commands, grab from one prompt to another one. All the commands between the two prompts will be reissued, one at a time.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

3. Graphics Commands

ad define a numbered annotation

ad *annotation_# option*

where

option can be

cap *message*	specifies a caption
mark	places a cross at the specified coordinates
arrow δ_x δ_y	draws a circle
circle *radius*	draws an arrow
line δ_x δ_y	draws a solid line segment
dline δ_x δ_y	draws a dashed line segment

Remarks

Annotations are all 2D: they are attached to the screen. For example, if the picture is rotated, the annotations will not be rotated with the objects. These annotations are used in conjunction with postscript to create pictures with annotations for documents such as this manual. Once the annotations are correct, then issue the postscript command and draw. These annotations were not intended to be very easy to use. You may have to experiment by reissuing the command several times until you get what you want. Each annotation has a positive integer identifier. Coordinates range from 0 to 1 with the origin at the lower left corner of the screen. Use **pad** to position it. The default position is the center of the picture. There are several types of captions. This is only for the physical window.

This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

aad add an annotation to the picture in the physical window

aad *annotation_#*

Remarks

See the **ad** command. This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

caption change or toggle caption

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

caption cap *comment*
or
caption off
or
caption on

Remarks

By default, a caption is displayed at the top of the picture. You can specify the caption with the **caption** command. If you do not specify a caption, but the problem has a title, then the title will be displayed (see the **title** command) as a caption. If there is no title or caption, then there will be no caption.

Below the caption is a description of the type of picture. This description will appear whenever the caption appears.

If you do not want the caption and picture description to appear, turn off their display with **caption off**. You can reverse the effect of **caption off** by issuing a **caption on** command.

This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

daad display all annotations in the physical picture

daad (no argument)

Remarks

See the **ad** command. This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

dad display a single annotation in the physical picture

dad *annotation_#*

Remarks

See the **ad** command. This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

dads display a list of annotations in the physical picture

dads *list_annotation_# ;*

Remarks

See the **ad** command. This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

display display with general hidden-line algorithm

display (no arguments)
or
disp (no arguments)

Remarks

This is slower than the other display algorithms, but it is found on all machines and the picture is very nice. The picture is a drawing of the mesh, with hidden-line removal. The same feature is available in the Environment window with the ***Hide*** and ***Draw*** buttons. See also **draw**, **poor**, and **tvv**.

The picture will also be drawn to a postscript file if the **postscript** option is on. This postscript feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

draw display without hidden line

draw (no arguments)

Remarks

The model will be displayed very fast, but the picture will not be as nice as you can get with the other display algorithms. The algorithm does not remove all hidden lines. The same feature is available in the Environment window with the ***Wire*** and ***Draw*** buttons and the **backplane** removal turned off. See also **poor**, **disp** and **tvv**.

The picture will also be drawn to a postscript file if the **postscript** option is on. This postscript feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

grid turn reference grid on or off

grid on
or
grid off

Remarks

This overlays the picture with a reference grid, or remove a reference grid from the picture. By default, the mesh picture has no reference grid.

When you issue a **grid on** command, a reference grid is superimposed on the picture. This grid is a box in the problem's global coordinate system. Along three of the edges of the box are tic marks to indicate values of the global coordinates. The tic marks are marked with integers. But those integers are not the values of the coordinates. Look in the lower left corner of the picture. There you will find a scaling factor. To get the value of a coordinate at a tic mark, multiply this scaling factor by the integer next to the tic mark.

Also in the lower left corner of the picture, near the scaling factor, are numerical intervals for each of the three coordinate directions. They tell you the location of the box in the global coordinate system.

The smallest box containing everything relevant is determined initially. When objects are changed, added, or removed from the picture, the frame of reference grid is not changed. The reference grid box will change when you update it to the new dimensionality with the **restore** command.

Once you have created a reference grid with a **grid on** command, you can remove it (thus restoring the default) by issuing a **grid off** command.

pad position an annotation in the physical picture

pad *annotation_#*

Remarks

This is followed by a mouse action in the interactive graphics mode or followed by the 2 screen coordinates. See the **ad** command. This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

poor poor man's hidden line removal

poor (no argument)

Remarks

The poor man's hidden line removal is a very simple method for reducing the number of mesh lines in the picture without the computation expense of removal all of the hidden lines. This is done by removing all faces of the mesh that are facing away from the viewer. You get the same results if you choose the ***Wire*** graphics option ***Draw*** in the Environment window and the **backplane** removal on (default). See also **draw**, **disp**, and **tvv**.

The picture will also be drawn to a postscript file if the **postscript** option is on. This postscript feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

postscript activate PostScript output

postscript *root_file_name*

Remarks

Once you issue this command, every time a picture is drawn on the screen with **draw**, **poor**, or **disp**, an equivalent PostScript[1] file, depicting exactly what the screen display shows. The file name will be constructed by putting a number at the end of the name given by the argument *root_file_name*. Thereafter, you can send the file to a PostScript printer or import it into a word processor or other program that accepts this file format.

To turn off PostScript output, type: **postscript off**

The **reso** command changes the quality of the postscript picture. Annotations can be added to the picture using **ad** and similar commands.

Use the **set** command to specify the line thickness using the **thick** option. It can range from 0.0 to 10.0.

These PostScript files also adhere to the minimum requirements of the PostScript Document Structuring

[1] PostScript is a trademark of Adobe Systems Incorporated.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Conventions, version 2.1, with additional features to support Adobe Illustrator[2]. As such, they also fulfill the minimum requirements of Encapsulated PostScript, version 2.0. But the PostScript files presently follow no more than the *minimum* requirements of Encapsulated PostScript. Thus they have no preview image. If you import a **True*Grid*®** PostScript file into a word processor, it will typically show a blank box on the screen. But your document will print correctly on a PostScript printer. The freeware GSview for the WINDOWS system is provided in the **True*Grid*®** distribution. This program can be used to add many types of preview images generated by **True*Grid*®**.

The **tvv** (***FILL*** button) graphics option does not work with the postscript command. Use the pop-up window with the right mouse while the mouse is in the window to activate the raster postscript options. This produces a large file by the name of tgimage.ps. While this is activated, each redraw of the physical window will rewrite this file with the new picture. Be sure to repeat this process to deactivate the writing of the tgimage.ps file and redirect the graphics back to the screen. Use the same pop-up window to do this.

This postscript feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

raad remove all annotations from the physical picture

raad (no argument)

Remarks

See the **ad** command. This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

rad remove an annotation from the physical picture

rad annotation_#

Remarks

See the **ad** command. This feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

[2] Adobe Illustrator is a trademark of Adobe Systems Incorporated.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rindex label reduced indices

rindex *option*
where *option* can be
on
off

Remarks

The computational window contains three index bars used heavily to select portions of the mesh. They are now labeled so that one can easily identify the i-, j-,and k-index bars. The partitions are also numbered along each of the bars.

The default is ON.

sdint toggle display of surface interior

sdint on
or
sdint off

Remarks

Turning off the interior surface lines allows much more rapid redraws, especially when combined with the wireframe mode (**draw**). Both the draw and fill graphics usually looks better with the interior lines turned off.

set define various graphic options

set *option argument*
where
option and *argument* can be any of:

pcolor *part red green blue*	to set the color of a part where red, green, and blue must be between 0.0 and 1.0 or negative to turn off
mcolor *red green blue*	to set the color of a material where red, green, and blue must be between 0.0 and 1.0 or negative to turn off
scolor *red green blue*	to set the color of a surface where red, green, and blue must be between 0.0 and 1.0 or negative to turn off

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

allpcolr *red green blue* resets the part color of all parts
allscolr *red green blue* resets the surface color of all surfaces
ldir *x-direction y-direction z-direction id* to set the lighting directions where id must be light source 1 or 2
lcor *red green blue id* to set the lighting color where red, green, and blue must be between 0.0 and 1.0 and where id must be light source 1 or 2
scol *red green blue* to set the specular color where red, green, and blue must be between 0.0 and 1.0
scon *constant* to set the specular constant
acon *constant* to set the ambient constant
dcon *constant* to set the diffusion constant
spow *even_positive_integer* to set the specular power
tv disp for automatic redrawing like **disp** command
tv draw for automatic redrawing like **draw** command
tv poor for automatic redrawing like **poor** command (same as **draw**)
tv none for no automatic redrawing
grid *color* for reference grid color (default blue)
marker *color* for condition markers from **di** command (default red)
mesh *color* for mesh color (default green)
rax *color* for **r**-coordinate color (default cyan)
sax *color* for **s**-coordinate color (default magenta)

cblind *switch* choose special color arrangement better suited for color blindness. The color blindness setting is preserved when the F4 function key is typed.

where *switch* can be

on turn on the color blindness adjustment
off turn off the color blindness adjustment

bgcolr *switch* choose between black and white physical, computational, 2D curves, and diagnostic graphics window background. The background color setting is preserved when the F4 function key is typed.

where *switch* can be

on white background for the physical window
off black background for the physical window

tax *color* for **t**-coordinate color (default white)

where

color can be one of **white**, **red**, **green**, **blue**, **cyan**, **magenta**, **yellow**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

thick *thickness* for line thickness

where the line

thickness must between 0.0 and 10.0 points (72 points = 1 inch). A thickness of 0.0 represents the minimum line width available. The thick setting is preserved when the F4 function key is typed.

Remarks

The **set tv ...** command has an effect when you issue a command that implicitly asks **True*Grid*®** to redraw the picture. When you enter a graphics command interactively, **True*Grid*®** will automatically redraw the picture, just as if you had explicitly issued a drawing command.

The line thickness setting only affects PostScript output and mesh lines in the physical and computational windows.

slice slice through the picture

slice *a b c d*
or
slice off

where the arguments define a slicing plane with global coordinates x, y, and z such that
a * x + b * y + c * z + d = 0

Remarks

The slicing plane is transformed (zoomed, panned, and rotated) along with the geometry. This slice only works in the merge phase with the fill graphics activated. It does not yet work for hardware graphics (OpenGL).

The ***SLICE*** button in the graphics menu activates a dialogue box and an intuitive interface for the use of this function. One can choose to form a slicing plane from either a point and normal or by three points. This is done by selecting points from the picture. Then the slicing plane can be shown. When the slice function is selected, the slicing plane is removed from the picture.

Example

```
block 1 3;1 3;1 3;1 3;1 3;1 3;
merge
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

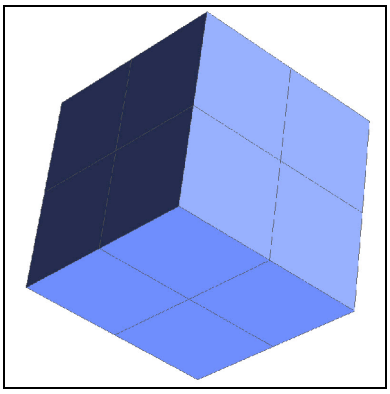


Figure 31 Simple block

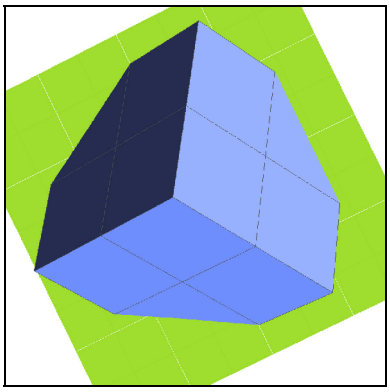


Figure 32 Slicing plane Shown

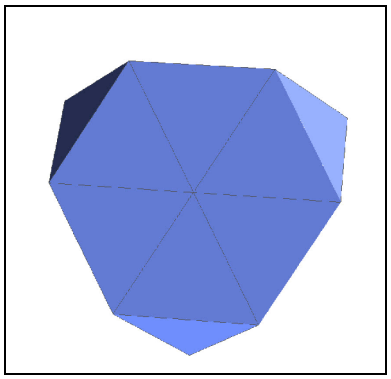


Figure 33 Sliced mesh

The slicing plane used in this example is defined by the equation:

$$x+y+z-6=0$$

There are various ways to define the slicing plane. The easiest way is to use the slice dialogue window. There are three ways to define the slicing plane in this dialogue window:

1. A point on the plane and the normal vector
2. The two points that designate the start and end of the normal vector.
3. Any three points that are not colinear.

Or, you can type the command and the 4 constants.

```
slice 1 1 1 -6
```

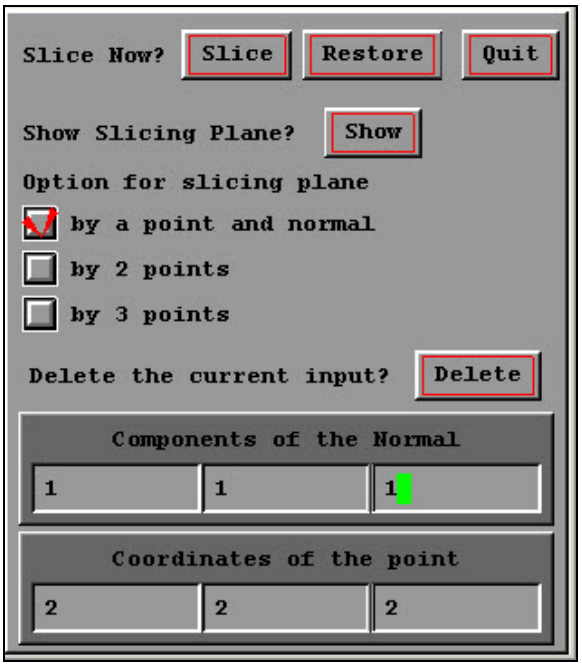


Figure 34 Dialogue for the slice command

triad turn triad on or off

triad off
or
triad on

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

This removes the coordinate system triad from the picture. The coordinate system triad is three little arrows representing the x, y, and z axes of the global coordinate system. It appears in the lower right corner of the picture.

When you rotate the picture, e.g. with the **rx** command, you rotate it with respect to the x, y, or z axes of the picture's coordinate system. The picture's coordinate system is fixed with respect to the screen and hence with respect to you. Thus rotating the picture will rotate the global coordinates with respect to you. The triad is there to tell you where the global coordinates are.

The triad is in the picture unless you turn it off with **triad off**. Once you have removed it you can put the triad back in the picture by issuing a command **triad on**.

tvv color and shaded display

tvv *(no arguments)*

Remarks

A **tvv** display has colored filled polygons. It also has two light sources with reflected light to add to the 3D effect. You may find that it makes the mesh easier to visualize. The same feature is available in the Environment window with the ***Fill*** and ***Draw*** buttons.

Some kinds of text labels from the **condition** and **labels** commands may not be available with **tvv**.

If you use the pop-up menu (right mouse button in the physical window) to select the output to be postscript instead of the screen, the picture will be saved in a postscript file called tgimage.ps. Be sure to return the output state back to the screen when you are finished with postscript so that you can continue viewing the mesh on the screen. This postscript feature only works when the ***Fast Gr.*** button is off (inactive OpenGl hardware graphics).

See also **disp**, **poor**, and **draw**.

zclip remove front portion from physical picture

zclip *screen_to_object screen_to_slice*

where

screen_to_object	is the distance from the screen to the object (default 1), and
screen_to_slice	is the distance from the screen to the slicing plane (default 0).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Thereafter, **True*Grid*®** will not display anything between the screen and the slicing plane. Both distances are measured in units where 1 is the length of the diagonal of the smallest box containing the object in the picture.

Remarks

This command is a good way to look at the inside of your model: slice off the front of it.

The units for the **zclip** command are based on the smallest box containing the object in the picture. This box is computed only when you issue a **restore** command. So if you add some-thing to your model or otherwise change what is in the picture, some of the new things may be inadvertently sliced out of the display - even if the object and slicing distances have their default values of 1 and 0. If this is a problem, you can simply issue another **restore** command. Or you can translate and rotate the new object until you see what you want.

4. Picture Controls

These commands transform the picture on the screen. Most often you will want to translate or rotate the picture, or zoom your view of it in or out. There are several commands which alter your view of a model. **L**, **r**, **u**, and **d** translate the model. **rx**, **ry**, and **rz** rotate the model around the center of the picture. **zf** and **zb** zoom forwards and backwards. If you mess up the picture too much, you can get the original picture with **restore** or **center**. There are a number of other less-used commands.

The mouse can also be used to control the picture. These mouse actions are equivalent to the commands in this section. When a precise movement is required, use the commands below. To activate the mouse, select either **Rotate**, **Move**, **Zoom**, or **Frame** in the Environment window. This selection is done with the left mouse button. Then move the mouse into the picture (physical or computational window). With the middle (left button if there are only two mouse buttons) mouse button pressed, move the mouse across the picture.

When the **Rotate** is selected, a wire frame of the object in the picture will track the mouse movement. When the picture is zoomed in, then the absolute rotation is scaled down so that the rotate continues to track the mouse. In order to override this scaling effect of mouse rotation, hold down the shift key while rotating. When the mouse button is released, the full picture is redrawn, depending on the type of graphics selected (**Wire**, **Hide**, or **Fill**).

Move translates the picture. Hold the middle (or left mouse button) down and slide the mouse across the screen. The object in the picture will track the mouse. Perspective can distort this a little. When the mouse button is released, the full picture is redrawn, depending on the type of graphics selected (**Wire**, **Hide**, or **Fill**).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The **Zoom** selection reacts only to the vertical motion of the mouse. Hold the middle (or left mouse button) down and slide the mouse up and down. This causes the wire frame to be scaled. When the mouse button is released, the full picture is redrawn, depending on the type of graphics selected (**Wire**, **Hide**, or **Fill**).

Frame is a combination of **Zoom** and **Move**. Select a new view of part of the picture by depressing the middle (or left) mouse button at one corner of the region and dragging the mouse to the opposite corner of the region. A rubber band frame will be draw as this is done. This will become the new region for the next automatic redraw of the picture, once the middle mouse button is released. To avoid the redraw, move the mouse completely out of the picture before releasing the mouse button. When the mouse button is released, the selected portion of the picture is redrawn, depending on the type of graphics selected (**Wire**, **Hide**, or **Fill**).

l move picture left

l *distance*

where

distance is in window units; 1.0 means the full width of the window.

Remarks

Move the picture to the left, where 1 unit is the size of the screen. A translation like this causes the center of rotation to be recalculated at the center of the screen and in the center of the z-coordinate range of the object in the center of the picture, unless the picture frame of reference was fixed. Except for the calculation of the center of rotation, this command is reversible by using a negative translation or the command **r** with the same translation.

r move picture right

r *distance*

where

distance is in window units; 1.0 means the full width of the window.

Remarks

Move the picture to the right, where 1 unit is the size of the screen. A translation like this causes the center of rotation to be recalculated at the center of the screen and in the center of the z-coordinate range of the object in the enter of the picture, unless the picture frame of reference was fixed. Except for the calculation of the center of rotation, this command is reversible by using a negative translation or the command **l** with the same translation.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

u move picture up

u *distance*

where

distance is in window units; 1.0 means the full height of the window.

Remarks

Move the picture up, where 1 unit is the size of the screen. A translation like this causes the center of rotation to be recalculated at the center of the screen and in the center of the z-coordinate range of the object in the center of the picture, unless the picture frame of reference was fixed. Except for the calculation of the center of rotation, this command is reversible by using a negative translation or the command **d** with the same translation.

d move picture down

d *distance*

where

distance is in window units; 1.0 means the full height of the window.

Remarks

Move the picture down, where 1 unit is the size of the screen. A translation like this causes the center of rotation to be recalculated at the center of the screen and in the center of the z-coordinate range of the object in the center of the picture, unless the picture frame of reference was fixed. Except for the calculation of the center of rotation, this command is reversible by using a negative translation or the command **u** with the same translation.

rx rotate about the x axis

rotates the picture about the *screen's* x-axis

rx θ

where

θ is the angle of the rotation, in degrees.

Remarks

This command rotates the picture on the screen. That is, it rotates the global coordinates with respect

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

to the *screen's* coordinate axes. The axes of the global coordinates are displayed in a corner of the screen. Normally the center of the screen is the origin of the screen's coordinate axes, hence the center of rotation. But you can change the origin of the screen's axes by combining a **fix** command with translation commands like **u**, **d**, **r**, and **l**. The **unfix** command will restore the default location of the origin.

ry rotate about the y axis

rotates the picture about the *screen's* y-axis

ry θ

where

θ	is the angle of the rotation, in degrees.

Remarks

See the remarks on **rx**, page 88.

rz rotate about the z axis

rz θ

where

θ	is the angle of the rotation, in degrees.

Remarks

This command rotates the picture about the *screen's* z-axis. See the remarks on **rx,** page 88.

trans translate to new center of rotation

trans *x_center_of_rotation y_center_of_rotation z_center_of_rotation*

Remarks

Translate to a new center of the picture and a new center of rotation, if the fix option is not active.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

fix freeze center of rotation

fix *(no arguments)*

Remarks

This command freezes the center of rotation to the present center of the picture. The center of rotation is used by the picture rotation commands **rx**, **ry**, and **rz**. Normally they rotate about the center of the screen. Thus if you translate the picture with respect to the screen, you will also translate the center of rotation (relative to the model). This command freezes the center of rotation to a fixed location relative to the model. See the remarks on **rx**, page 88. The **unfix** command will restore the center of rotation to normal.

unfix return center of rotation to picture

unfix *(no arguments)*

Remarks

See the remarks on **fix**, page 90.

scale scale all coordinates

scale *scaling_factor*

Remarks

Scale all coordinates. This command is not cumulative. It is the same as issuing the **xscl**, **yscl**, and **zscl** commands with the same scale factor. Coordinates are scaled after translations and rotations and before perspective and zooming. This can cause distortion because the perspective will make it appear as though your eye had gotten closer or farther away from the object. In most cases, the zoom is preferred.

xscl scale x-coordinate

xscl *factor*

scale the x-coordinates. This command is not cumulative. Coordinates are scaled after translations

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

and rotations and before perspective and zooming. This can cause distortion because the perspective will make it appear as though you eye had gotten closer or further away from the object. In most cases, the zoom is preferred. This feature can be very useful when the range of the x-coordinates are much smaller then the range of coordinates in the other directions.

yscl scale y-coordinate

yscl *factor*

Remarks

Scale the y-coordinates. This is not cumulative. Coordinates are scaled after translations and rotations and before perspective and zooming. This can cause distortion because the perspective will make it appear as though you eye had gotten closer or further away from the object. In most cases, the zoom is preferred. This feature can be very useful when the range of the y-coordinates are much smaller then the range of coordinates in the other directions.

zscl scale z-coordinate

zscl *factor*

Remarks

Scale the z-coordinates. This is not cumulative. Coordinates are scaled after translations and rotations and before perspective and zooming. This can cause distortion because the perspective will make it appear as though you eye had gotten closer or further away from the object. In most cases, the zoom is preferred. This feature can be very useful when the range of the z-coordinates are much smaller then the range of coordinates in the other directions.

zb zoom back

zb *zoom_factor*

Remarks

Zoom backward by a scale factor. This operation is performed on the coordinates after translations, rotations, scaling, and perspective. It has a similar effect that a zoom lens on a camera where the perspective will be unaffected by the zoom. This is reversible by using the reciprocal of the zoom

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

factor or by using the **zf** command with the same zoom factor.

zf zoom forward

zf *zoom_factor*

Remarks

Zoom forward by a scale factor. This operation is performed on the coordinates after translations, rotations, scaling, and perspective. Its effect is similar to that of a zoom lens on a camera where the perspective will be unaffected by the zoom. This is reversible by using the reciprocal of the zoom factor or by using the **zb** command with the same zoom factor.

angle perspective angle

angle *angle* where the angle is in degrees

Remarks

This command defines the perspective angle. The default is about 17 degrees. Set the angle to 0 for an orthogonal projection onto the screen. The angle must be between 0 and 180, excluding 180.

reso change display resolution

reso *width*

where

width is the width in pixels of the (square) picture

Remarks

True*Grid*®'s device-independent hidden-line algorithm involves an internal computational picture whose resolution should correspond to the required detail in the picture. The ***Hide*** graphics button in the environment window and the **disp** command use the device-independent hidden-line algorithm to draw the picture on the screen and, optionally, to a postscript file using the **postscript** command. The picture is always square, and the default resolution is 512×512 pixels. Increasing the resolution requires more memory and more calculations. For example, if you tripled the pixel width by a command like

```
reso 1536
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

then the new 1536×1536 picture would have nine times as many pixels. So **True*Grid*®** would need nine times as much memory for it, and most calculations involving the picture would take nine times as long.

The resolution should be used primarily when there are numerous lines that are so close in the picture that they cannot be distinguished. However, if the screen (or the printer drawing postscript files) cannot resolve the lines, it is a waste of computer memory and time to increase the internal resolution. Secondarily, when one object is partially obscuring another, a higher resolution will calculate the region of overlap more accurately within the width of a pixel. There is another advantage of increasing the resolution, when selecting nodes from the picture. If the nodes are found at the same pixel, the node selection becomes ambiguous. By increasing the resolution, the pixels become smaller, separating the nodes so each can be selected with a separate mouse actions.

restore return to original or fixed view

restore *(no arguments)*

Remarks

Return the orientation of the picture to the original default position corresponding to the screen coordinate system or, in the case that the **fix** command was used, to the saved fixed orientation. This is useful when you get lost in the picture and need to start over. This command also recalculates the smallest box that will contain all of the active parts, surfaces, curves, and block boundaries in the picture. This box is used to scale the picture in order to automatically view everything. You can view the containing box by using the **grid** command. When the fix option is active, no calculations are made and all parameters controlling the picture are restored to those that were in effect when the picture frame of reference was fixed.

The ***Rest*** button in the environment window performs the same function.

center fit picture to the screen

center *(no arguments)*

Translate and scale such that all active objects fit into the picture.

Remarks

The key difference with this command, compared to the **restore** command, is that the picture is not

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

returned to the default position. The rotations of the picture are preserved. One use of this command is to frame in onto a subset of objects in the picture. First, remove all the objects except those to be framed. Then center the picture. Finally, return all of the other objects to the picture.

The ***Cent*** button in the environment window performs the same function.

5. Computational Window

True*Grid*® has two types of mesh objects that can be selected using the mouse. These selected portions of the mesh can be used for various reasons. The two types are Regions and Index Progressions. Please note that the ability to make these types of selections in the mesh are available only in the part phase because the block structure of the part (or its topology) is only known while in the part phase.

A **Region** is described by six numbers, the minimum and maximum values for each of the three reduced indices (reduced indices are described in the introduction). Thus, a region can be anything that is "rectangular" in computational space: a vertex of the mesh, an edge of the mesh, a face of the mesh, or a prism shaped volume or block in the mesh.

An **Index Progression** can be any part of the mesh that you can select with the mouse in the Computational Window. An index progression might describe one region or many regions. For example, all six faces of a cube can be described by one index progression.

By using your mouse, you can highlight a portion of the physical or computational mesh and select that portion as input for a command. The distinction between Regions and Index Progressions is noteworthy because some **True*Grid*®** commands apply to Regions and others apply to Index Progressions. Often a command comes in two versions, one for Regions (e.g. **sf**) and the other for Progressions (e.g. **sfi**). An "i" at the end of a command name generally indicates that it is applied to Index Progressions.

There are actually four different techniques using the mouse to select a Region or Index Progression. Each technique has its advantages. It is best to become proficient in all four techniques so that you can easily select objects of the mesh. You will need to do this many times in the process of creating a mesh. The four methods are:

1. Index bars
2. Click-and-drag in the computational window
3. Function keys **F5** and **F6** in the physical window
4. Pick Region and click-and-drag in the physical window

This section of the manual discusses only the index bar and the click-and-drag method in the computational window. See the section on selecting mesh objects in the physical window to learn about

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

these additional methods.

The pictures in the following examples do not show a default feature found in the computational window. This feature frames the region around the index bars. This frame has been removed using the **ibzone** command.

Selecting Regions and Index Progressions with the Index Bars

In the Computational Window, you can use the mouse to select **dots** and/or **segments** along the **index bars**. The **index bars** are the 3 green lines (formed from **segments** between **dots**) with small half discs (referred to as **dots**). These three bars are associated with the three directions in the computational mesh and referred to as the i, j, and k-index directions. They are found in the top (k-index bar), bottom (i-index bar), and right (j-index bar) side of the computational window.

Your selection will also appear as Regions of the computational and physical meshes. This is how you can choose Regions and Index Progressions as arguments in commands. Once you have finished graphically selecting a Region or Progression, a **Control-A** or **F1** will copy it into a command's dialogue box (when the mouse is over the dialogue box) or text command line (otherwise). The **Control-D** or **F2** will clear all selections in the computational window.

To toggle a **dot** on or off along an index bar, first click on the **F2** function key and then left-click your mouse in the neighborhood of the **dot**. You will have to experiment a bit in order to determine the exact neighborhood corresponding to each **dot**. The color of the **dot** will change, to red for **on** or green for **off**. Moreover, the dot will be white when the Mouse Pointer is in the neighborhood. Geometrically, a single highlighted **dot** selects a face, two highlighted **dots** (on different bars) select an edge, and three highlighted **dots** (on different bars) select a vertex. To understand the affect of the defaults in this selection, you need to understand the affect of selecting a **segment** of an index bar.
A **segment** is the part of an index bar which lies between two **dots**. You toggle **segments** on or off by a click-and-drag action of the mouse. Move the Mouse Pointer over the **dot** at one end of the **segment**; the **dot** will turn white. Depress the Left Mouse Button and keep it down as you drag the mouse along the index bar to another **dot**. As you drag the mouse, **segments** will change color to indicate that they are being turned on or off, red for **on** or green for **off**. Once you have selected the **segments** you want, release the Left Mouse Button. Remember that this is a toggling action. So, in order to deselect a **segment**, repeat the click-and-drag action.

When you turn **dots** and **segments** on, you are selecting the corresponding Regions in the computational and physical meshes. You can select a block (3D prism) by selecting **segments** in each of the i, j, and k index bars. You can select faces by selecting **segments** in two of the bars and **dots** in one bar. Edges are selected by choosing **segments** in one bar and **dots** in the other bars. Vertices are selected by choosing **dots** in all three bars.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

If nothing is selected in an index bar, it will be interpreted as selecting all **segments** in that bar. This is the default referred to above. The exception to this is that if nothing is selected in all three index bars, there will be no highlights in the mesh, although it is still interpreted as selecting the entire mesh.

Color table for graphical region selection

As you select regions of the mesh, they are highlighted. Each type of selection has a different highlighting color.

Color	Meaning
Blue	selected edge
Green	no selection
Yellow	selected face
Cyan	selected block
White	mouse on a dot
Magenta	boundary of selected deleted region

Key bindings pertaining to highlighting and region selection

Control-P toggle on or off the continuous highlighting of slicing planes
Control-D clear the current highlighting
F2 clear the current highlighting
Control-A print the progression (or region) to the command line or to a dialogue box
F1 print the progression (or region) to the command line or to a dialogue box

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Examples of Index Bar selections

From **True*Grid*®**'s Control Phase[3], issue the command

```
block 1  3  6  7  ; 1   2   4   6   8  ; 1  3  4 ;
      1. 2. 3. 4. ; 0. 2.5 3.1 4.3 5.2 ; 1. 2. 3.
```

You have just created a block mesh with several partition points, at reduced indices i=1,2,3,4; j=1,2,3,4,5; and k=1,2,3. The last twelve numbers entered represent the physical coordinates of the vertices defined by these reduced indices.

This command has put you in Part Phase. The Physical, Computational, and Environment Windows will appear. In the computational window, the lower index bar contains 4 dots corresponding to the four values in the i-index list of the block command above. The vertical index bar contains 5 dots corresponding to the five values in the j-index list of the block command above. The upper index bar will contain 3 dots corresponding to the three values in the k-index list of the block command above. Click on the ***Both*** and ***Draw*** button in order to see both the physical and computational views of the mesh.

Now move the Mouse Pointer near the index bars in the Computational Window. You will see that, as you move the mouse across one of the index bars, the highlighted slicing planes follow the Mouse Pointer in both the Physical and Computational windows. If you do not want to see this continuous highlighting of slicing planes, toggle the feature with **Control-P**.

Now, click and drag the Mouse Pointer (see page 95) to select the middle segment of the lower index bar, the middle two segments of the vertical index bar, and the first segment of the upper index bar. **Figure 35** shows which segments to select.

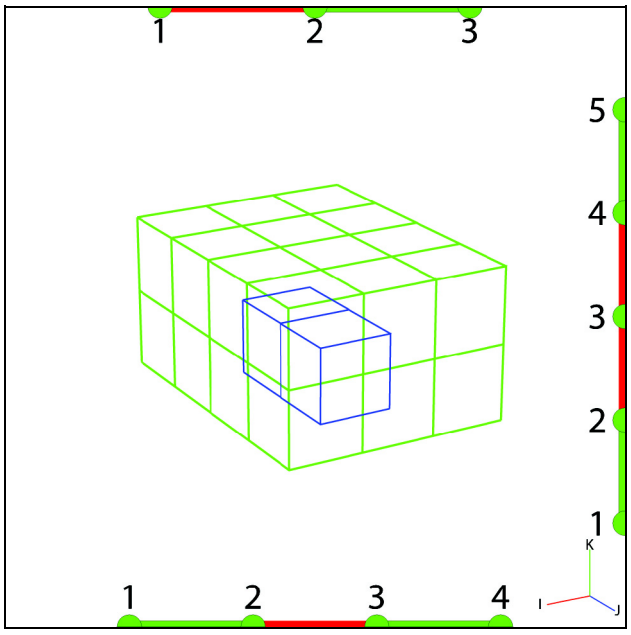


Figure 35

[3]**True*Grid*®** is initially in the Control Phase. From the Merge Phase, you can get to the Control Phase by entering the **control** command. From the Part Phase, the **endpart** or **control** command will put **True*Grid*®** in the Control Phase.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

You should now see 2 blocks in the picture that are colored cyan. **True*Grid*®** uses this color to indicate that you have selected a block region of the mesh (cyan is a mixture of green and blue at full intensity, the opposite of red).

You also can select faces in the physical mesh; they are plane sections in the computational mesh. You can access any number of plane sections at once. For example, select the second dot on the lower index bar (**Figure 36**).

Once you do that, the cyan-colored segments will disappear and a yellow plane will appear. **True*Grid*®** uses yellow to indicate that you have selected a planar section of the computational mesh (that is, a face in the physical mesh).

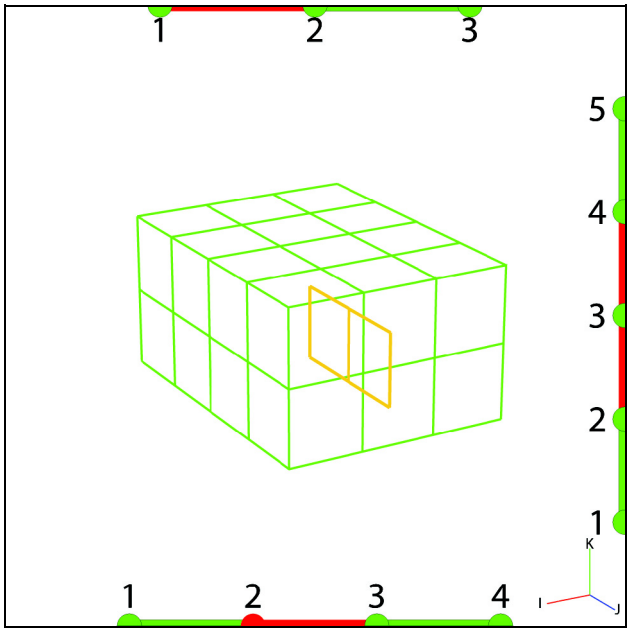


Figure 36

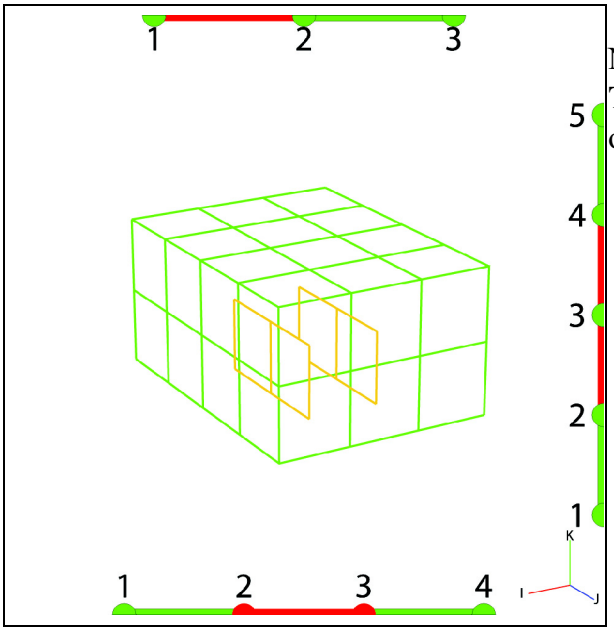


Figure 37

Now select the third dot on the lower index bar. **True*Grid*®** will highlight another face, the face on the opposite side of the cube (**Figure 37**).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

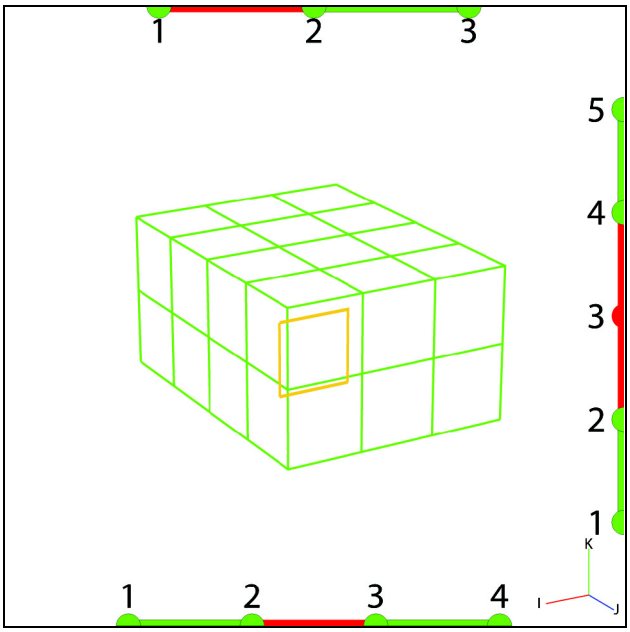


Figure 38

Next, deselect the second and third dots on the lower index bar and select the middle dot (third dot) on the vertical index bar (**Figure 38**).

You have just selected a plane that slices the original selected volume into two equal pieces. You can select any number of planes by selecting dots. Try it! For example, **Figure 39** shows how to select all six outer faces of the original rectangular box, as well as an interior plane in the middle. The **Figure 39** is created by the hidden line removal option, so it is similar to **Figure 35**. The difference is in the color of the selected region (**Figure 35** - cyan, **Figure 39** - yellow)

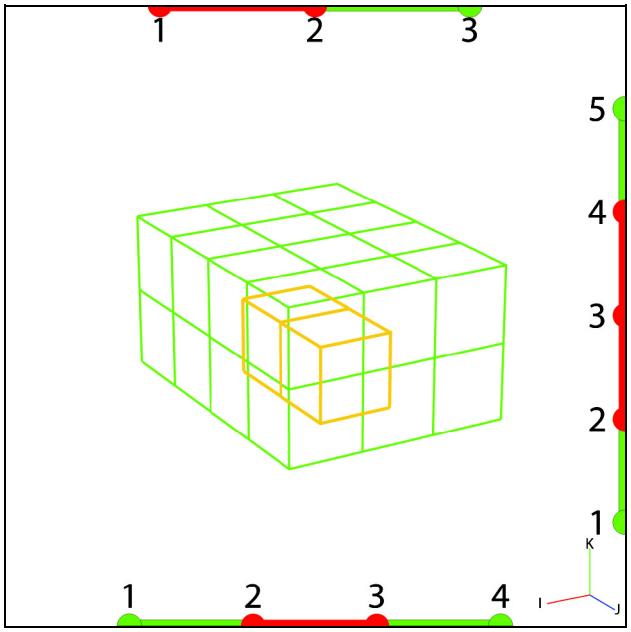


Figure 39

Figure 40, **Figure 41**, **Figure 42** and **Figure 43** show four different ways to choose exactly the same face region. However, they will be very different if you choose various other dots. For example, try the second dot of the vertical index bar.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

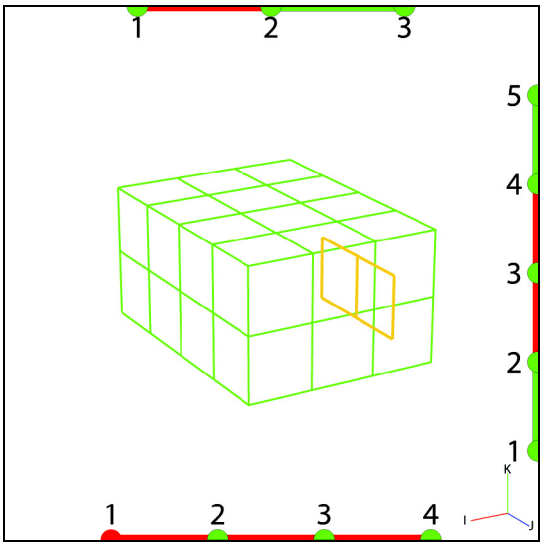


Figure 40

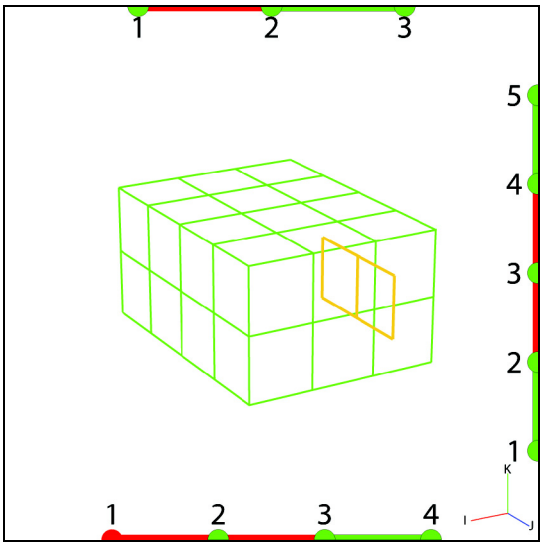


Figure 41

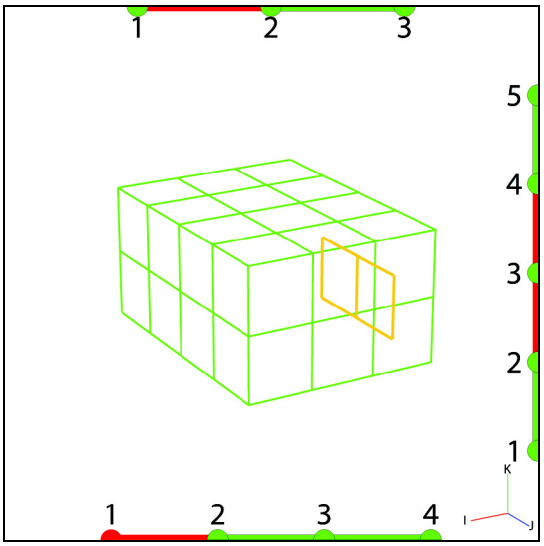


Figure 42

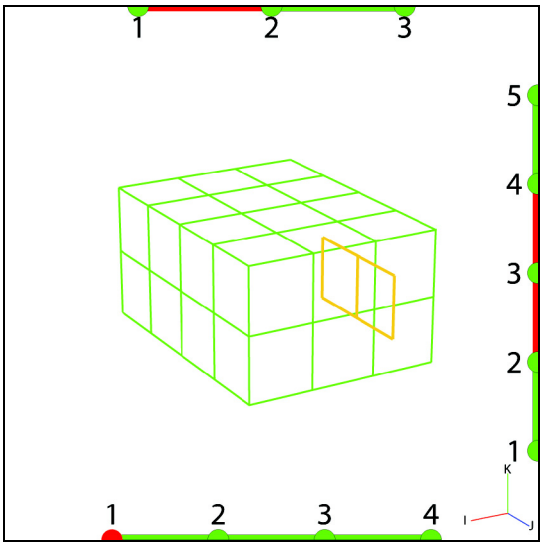


Figure 43

The way that selecting dots chooses blocks and faces is based upon the principle of superposition.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

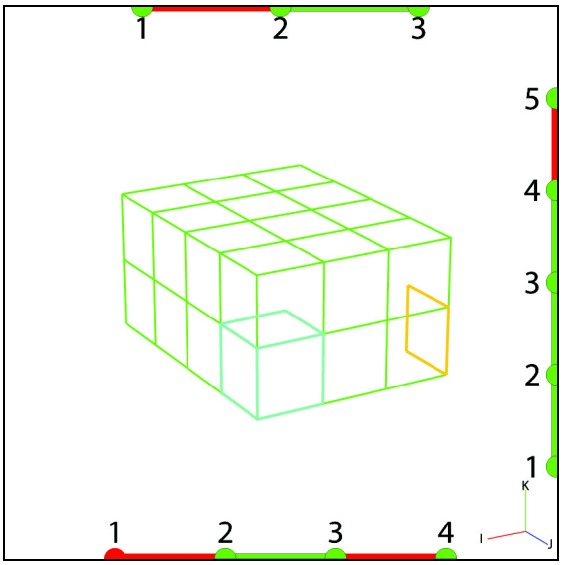


Figure 44

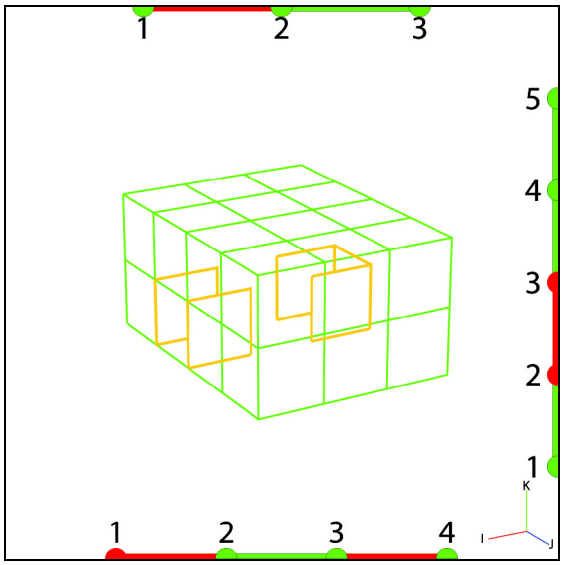


Figure 45

For example, **Figure 43** can be viewed as the superposition of the **Figure 44** and **Figure 45**. See the color table, page 96, for the details of how the colors are chosen.

There is one very special exception to the principle of superposition that occurs when you choose edges. You can choose any number of edges *in one direction only* by selecting dots *only* in two directions and segments *only* in the other direction. Selected edges appear blue.

So far, we have seen all the colors **True*Grid*®** uses to show what you have selected. In certain situations, **True*Grid*®** will use the one remaining color, magenta, to show what you have deleted (Magenta is a mixture of red and blue, the opposite of green). In the example, select index bar segments as shown in 101.

Click on the ***Delete*** button. (command **dei** in the command line). You have just deleted the selected region.

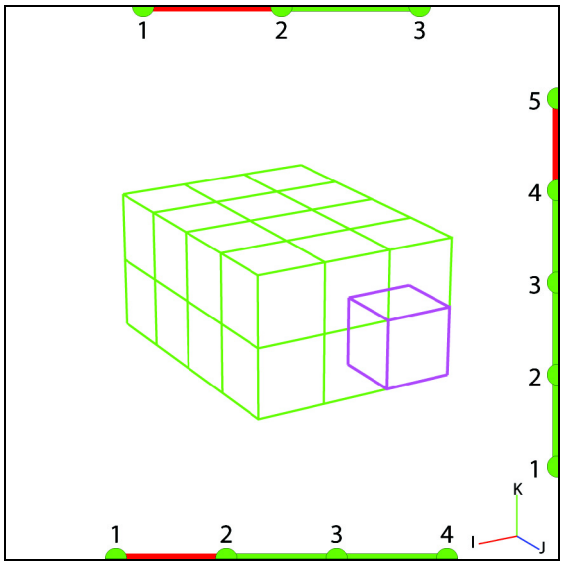


Figure 46

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Try the same thing with a dialogue box. Either issue **dial dei** from the text window, or go to the ***Mesh*** submenu and select ***dei*** by left-clicking the mouse. Now press the **F2** key to clear the current progression from the dialogue box. Then select a region of the mesh as shown by the index bars in 101, 102. Press the **F1** key. **True*Grid*®** will copy your graphical selection into the dialogue box. Issue the **dei** command by pressing the ***Exec/Quit*** button at the bottom of the dialogue box. Finally, click on the ***Draw*** button to see the new object.

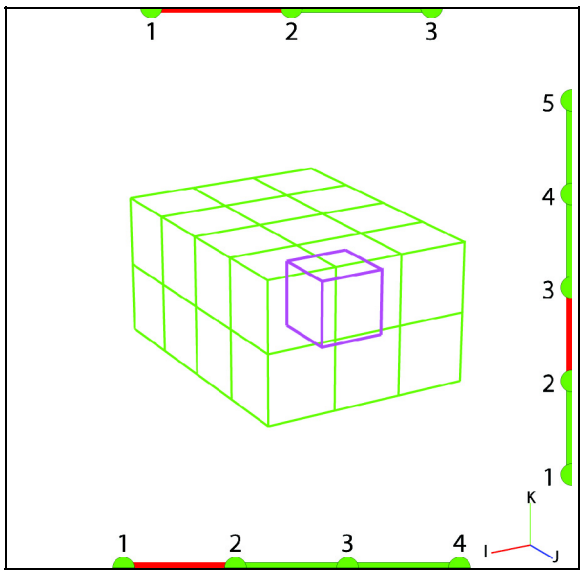


Figure 47

Next, activate the history window. One way to do this is by issuing the **True*Grid*®** command **history**. Middle-click your mouse on either of the two lines that begin with **progression**. This will highlight the regions that you just deleted. The regions are no longer there, but faces on their borders do still remain. Now these faces are colored magenta. **True*Grid*®** uses magenta for just this situation. You have selected a piece of the mesh that includes a volume, and part of that volume has been deleted, and the selected region contains (or borders on) a face that borders on a deleted region. This coupling of the history and computational window is important when you have a complex problem with an error in your input. The history window can be used to find the command(s) in error and to correct the error(s). The history window is you primary tool in debugging your mesh.

Selecting a Region with Click-and-Drag in the Computational Window

A single vertex, edge, face, or block can be selected from the picture of the computational mesh using a click-and-drag with the left mouse button. To select a vertex, move the mouse close to a vertex in the computational mesh and click the left mouse button. The vertex in both the computational and physical window will be highlighted in red.

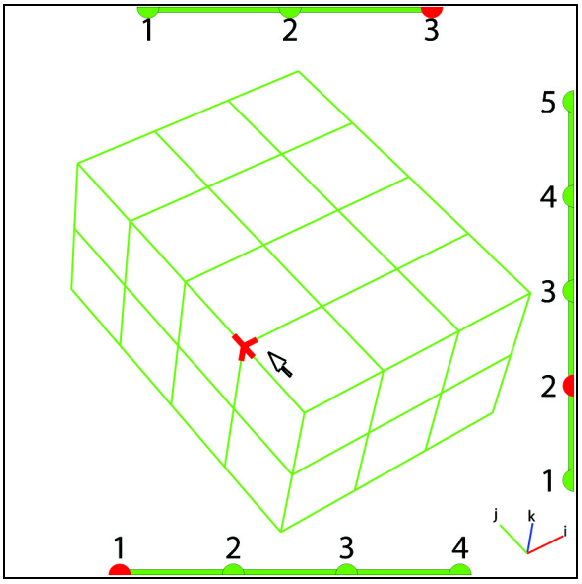


Figure 48 Vertex with click-and-drag

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

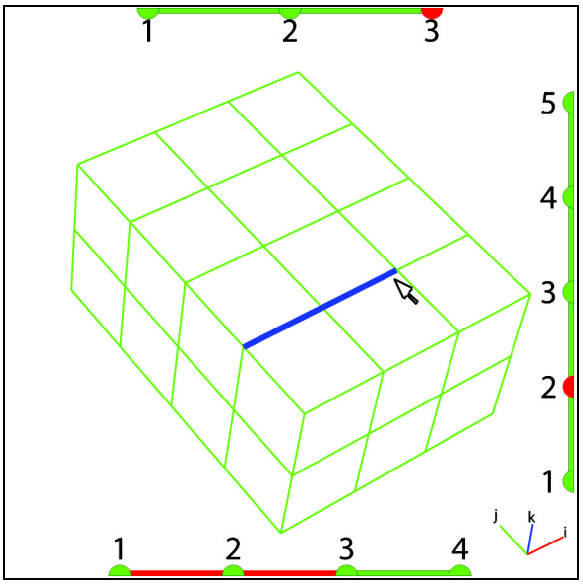


Figure 49 Edge with click-and-drag

By holding the mouse button down and moving the mouse to trace an edge of the mesh, you will be selecting that edge. As long as you keep the mouse button depressed, you can continue to move the mouse and change your selection. Both the highlighting in the mesh and the index bar selections are changed as you move the mouse. This selection process is completed by releasing the mouse.

Each time you depress the left mouse button, it starts a new selection process by initializing the selection to the closest vertex. To select a face of the mesh, start the click-and-drag procedure at one corner of the face and drag to the opposite corner of the face.

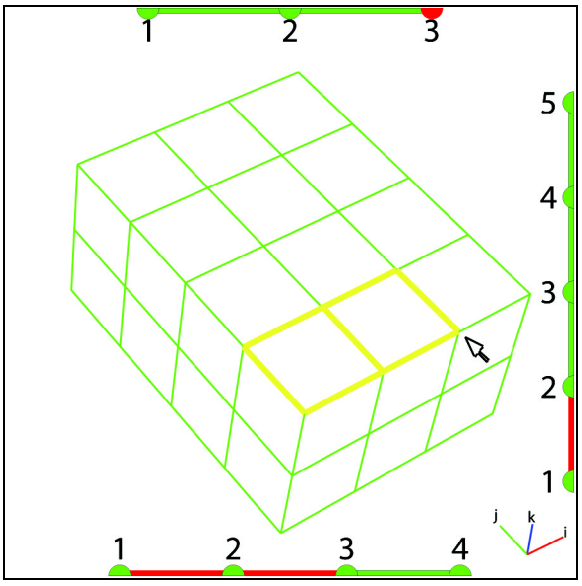
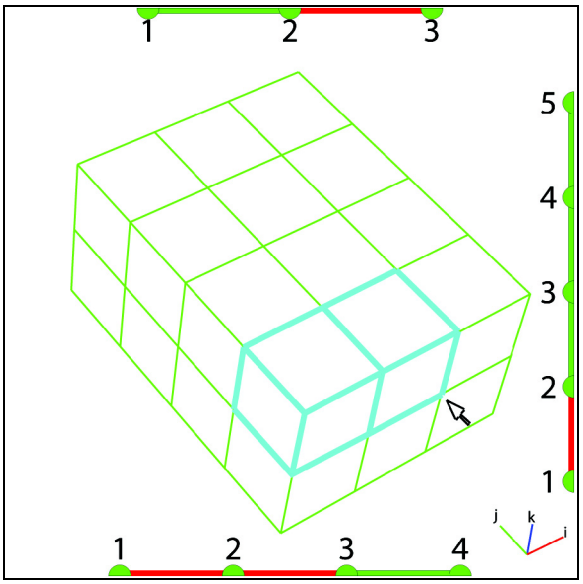


Figure 50 Face with click-and-drag

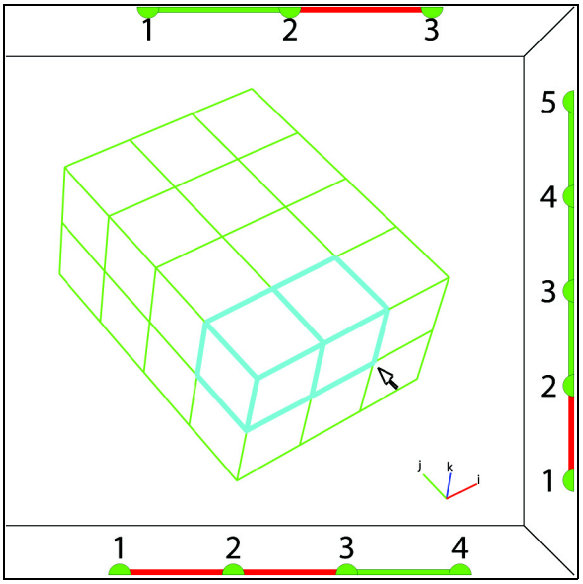
Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved



To select a block, start at one corner of the block and click-and-drag to the opposing diagonal corner of the block and release the mouse.

Figure 51 Block with click-and-drag

Index Bar Zone



These two methods can interfere with each other if the computational mesh is near an index bar because there is an area around the index bars, which is relatively large, that affects the index bar and not the computational mesh. For this reason, you can display the zone that is owned by the index bars using the **ibzone** command (the default is on). The picture of the computational mesh is clipped so that it never enters the index bar zone.

The index bar zone is kept relatively large so that one can be sloppy when making selections using the index bar. It is worth while to spend some time spent practicing with the index bars.

Figure 52 Index Bar Zone

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

6. The Environment Window

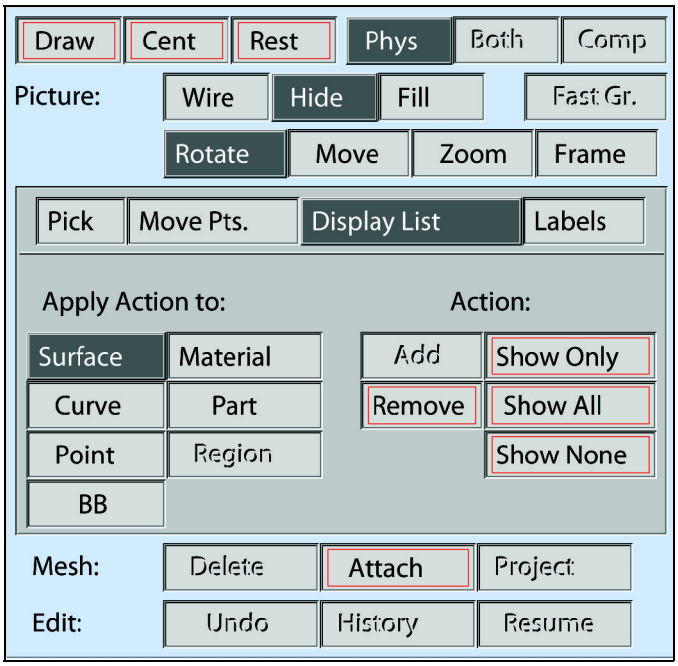


Figure 53 Environment Window

General

The buttons in the Environment Window control frequently used graphics and interactive mesh operations. Every function which can be invoked by a button in the Environment Window can also be invoked using the dialogue boxes through the menu system or by typing a command in the text window. Only a fraction of the commands in the menu and dialogue system are available through the Environment Window. All buttons in the Environment Window respond only to the Left Mouse Button. Certain buttons may be inoperative at different times, and the labels for these buttons appear "broken" and "grayed out".

Choosing the Type of Picture

Figure 54 Type of Picture Buttons

There are three types of pictures available: a simple line drawing (***Wire***), a hidden line drawing (***Hide***), and a colored polygon fill picture with hidden-surface removal (***Fill***). A hardware graphics option (***Fast Gr.***) is also available for machines supporting OpenGL. To get the OpenGL hardware graphics option, you must be running the OpenGL version of **True*Grid***®. The OpenGL version is easily

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

identified because it is the default. The single precision OpenGL version is named tg and the double precision OpenGL version is named tgd. When a hardware option is present, both a line drawing and a polygon fill picture with hidden-surface removal are available (along with lighting, fogging, and many other hardware features).

In order to set the picture type, press the Left Mouse Button on one of the default graphics option buttons, ***Wire***, ***Hide***, or ***Fill***. Whenever **True*Grid*®** generates a new picture, the new picture will be of the chosen type. After selecting a new picture type, click on the ***Draw*** button to a new picture. The ***Wire*** option sets the picture type to a line or wire drawing (**Figure 55**). The ***Hide*** option is a line drawing with hidden lines removed (**Figure 56**). The ***Fill*** option (available only in the Merge Phase), sets the picture type to a color polygon fill picture with lighting and hidden-surface removal (**Figure 57**). When hardware graphics is available with the use of the OpenGL version of **True*Grid*®**, then the hardware, ***Fast Gr.***, button is a toggle. When the ***Fast Gr.*** button is pressed, the ***Hide*** and ***Fill*** options produce very similar pictures; both result in a color polygon fill picture with hidden-surface removal. The only difference is that the ***Fast Gr.*** version has no perspective (see the **angle** command). The ***Wire*** option for hardware selects a line drawing (usually with lighting).

See also: **draw**, **disp**, **set tv** commands.

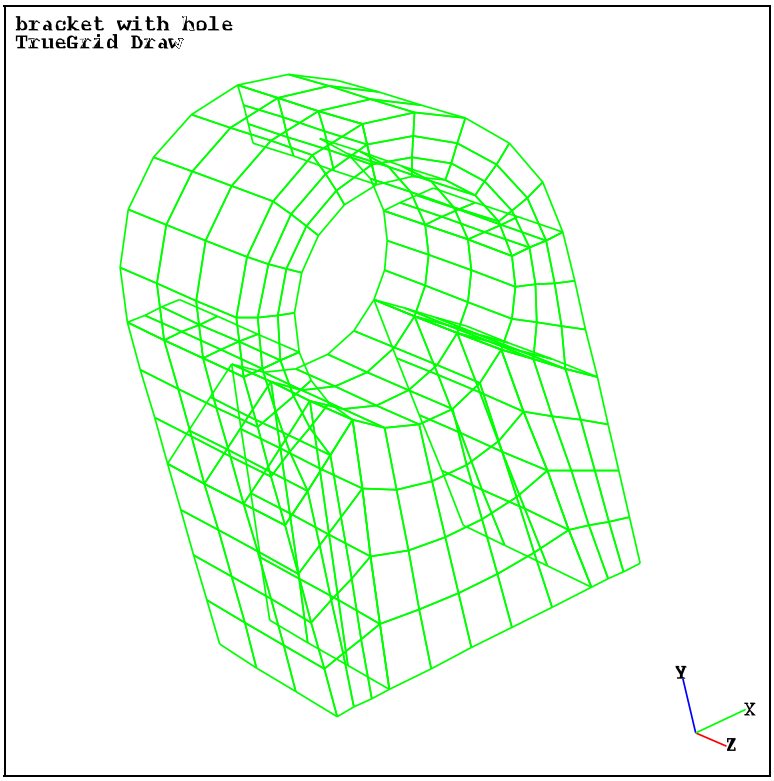


Figure 55 Wire Picture

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

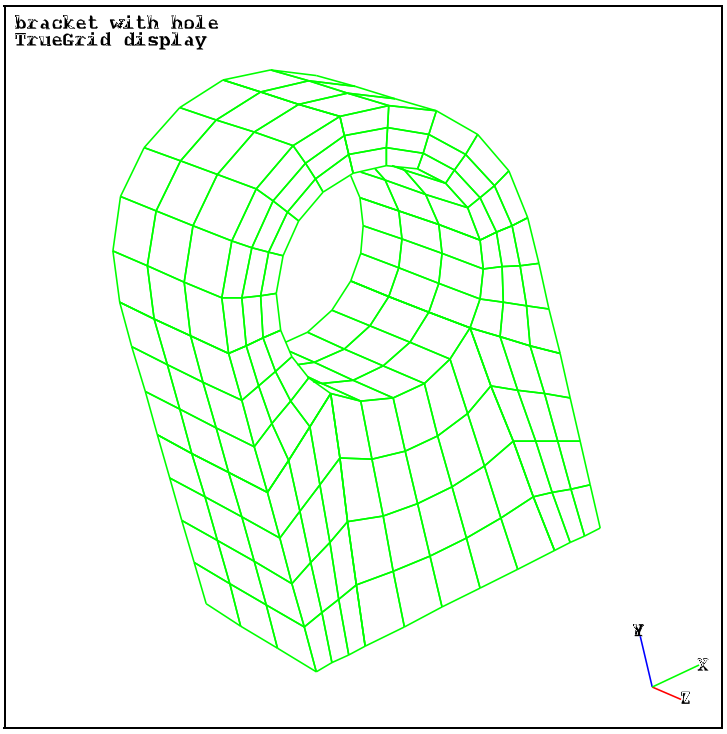


Figure 56 Hide Picture

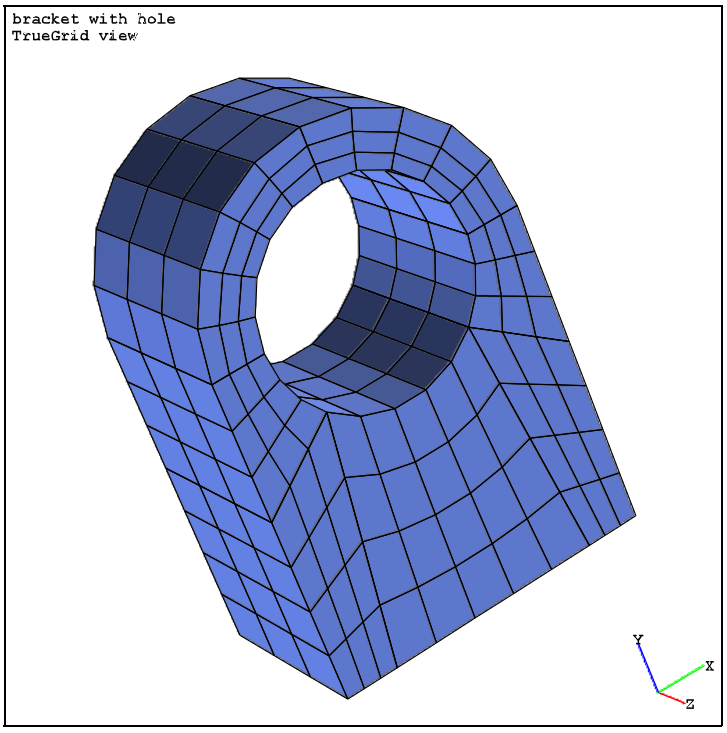


Figure 57 Fill Picture

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Selecting the Windows to be Redrawn

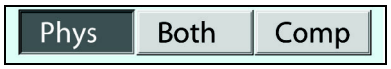


Figure 58 Phys Button

The ***Phys***, ***Both***, and ***Comp*** button group (**Figure 58**) determines which window(s) manually-issued graphics commands will affect, as well as what window(s) the ***Draw***, ***Cent***, and ***Rest*** buttons will redraw. When more than one Physical Window is on the screen, then only the Physical Window with focus will be redrawn.

When ***Both*** is selected, the motion of the physical and computational mesh are coupled. This is true for mouse driven motions using the Middle mouse button to ***Rotate***, ***Move***, ***Zoom***, or ***Frame***. This is also true for keyword driven motion commands such as **rx**, **ry**, **rz**, **u**, **d**, **l**, **r**, **zf**, and **zb**.

The ***Comp*** and ***Both*** buttons are grayed out in the Merge Phase because there is no Computational Window available.

The following keyword commands in the Part phase will also toggle between these three options.

phys turn the Phys button on

phys (no arguments)

both turn the Both button on

both (no arguments)

comp turn on the Comp button

comp (no arguments)

Generating a New Picture

Figure 59 Draw Buttons

In order to draw a new picture, press either the ***Draw***, ***Center***, or ***Restore*** button. Press the ***Draw*** button to generate a new picture. Press the ***Center*** button to center what is in the current picture. (This

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

is a good way to fill the window with the current view.) Press the ***Restore*** button to generate a new picture in the original, untransformed orientation. This function applies only to the windows selected by the buttons in **Figure 58**.

Dynamically Moving the Picture

Figure 60 Motion of Picture Buttons

Interactive rotation, translation, zoom and framing (outlining an area which is to become the displayed picture) is available for both the Physical and Computational Windows using the Middle Mouse Button, 60. Which action is performed depends on which of the ***Rotate***, ***Move***, ***Zoom***, or ***Frame*** buttons is depressed. Only one button can be depressed at a time and the program initiates with the ***Rotate*** option selected.

The action is performed by pressing the Middle Mouse Button in the window whose picture is to be altered, dragging the mouse to some new location while the Middle Mouse Button remains pressed, and then releasing the button. Note: If you find yourself with the Middle Mouse Button down for the Frame function and you change your mind, simply move the cursor out of the current window before releasing the button. This will result in no Frame change being performed. When applying the Rotate, Move or Zoom function, the center mouse button continues to work when dragged outside the Physical or Computational Window.

Rotating the Picture

In order to rotate the picture, press the ***Rotate*** button with the Left Mouse Button. Then perform a click-and-drag operation using the Middle Mouse Button on the window containing the picture that is to be rotated. A skeleton picture will dynamically track the mouse motion as the mouse is moved across the screen. When the mouse button is released, a new picture is automatically displayed. The object is rotated relative to the physical length defined by the click-and-drag operation. When you have zoomed in a lot, this may be a very slow rotation. In these circumstances, a fast rotation can be invoked by holding the **Shift** key while rotating. **Figure 61** is created from **Figure 56** by the ***Rotate*** option. See

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

also: **rx**, **ry**, **rz**, **dpic**, **rpic** commands.

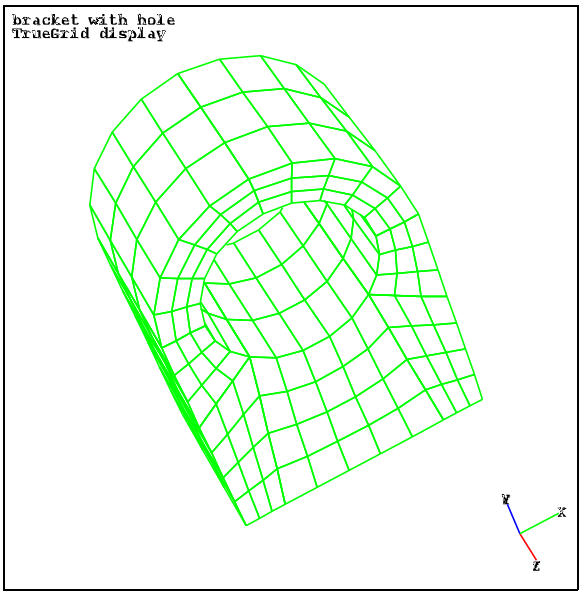


Figure 61 Rotated Picture

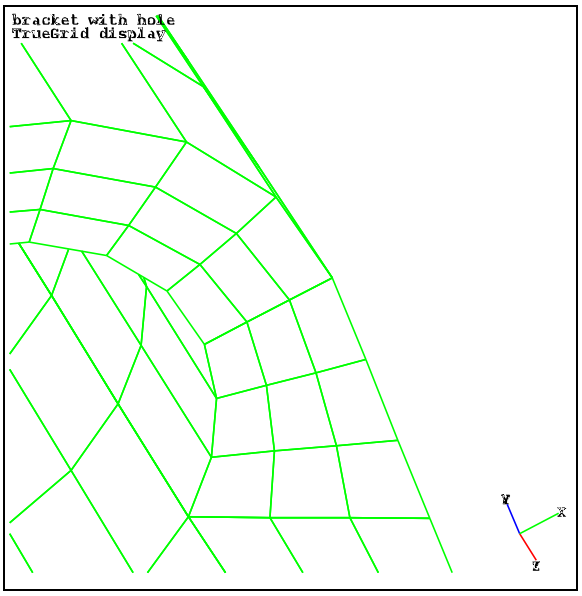


Figure 62 Frame Zoomed Picture

Framing a Picture

The ***Frame*** option is a combination of zoom and translate. Use the ***Frame*** option by pressing the ***Frame*** button, and then by performing a click-and-drag operation using the Middle Mouse Button in the window containing the picture you wish to alter. While the mouse button is down, a rectangle outlines what is currently selected to be the new picture. This new picture will be displayed when you release the Middle Mouse Button. In order to cancel a ***Frame*** operation after you have depressed the Middle Mouse Button, simply drag the cursor outside of the window and release the button. **Figure 62** is created by the ***Frame*** option from **Figure 61**. See also: **zb**, **zf**, **l**, **r**, **u**, **d**, **dpic**, **rpic** commands.

Translating the Picture

In order to translate the picture, press the ***Move*** button with the Left Mouse Button. Then perform a click-and-drag operation using the Middle Mouse Button in the window containing the picture that is to be translated. A skeleton picture is dynamically redrawn while the translation is being performed. Release the Middle Mouse Button when the picture is in the desired position. A new picture is automatically displayed.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 63 is created by from **Figure 62** by the ***Move*** option. See also: **l**, **r**, **u**, **d**, **dpic**, **rpic** commands.

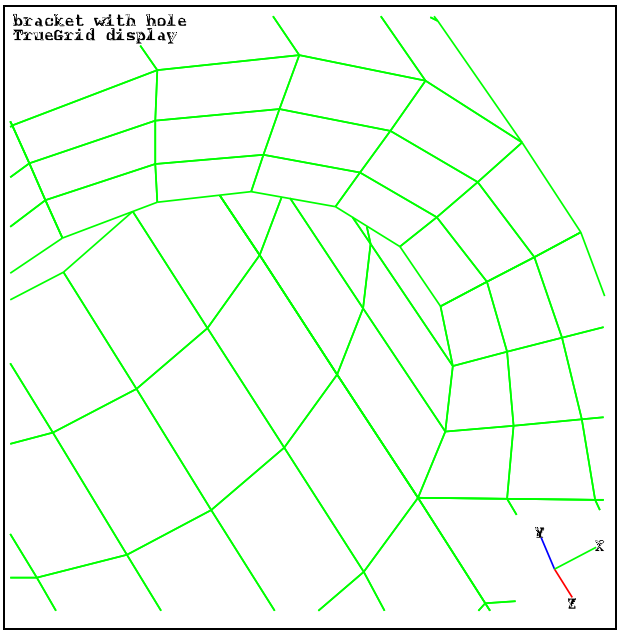


Figure 63 Translated Picture

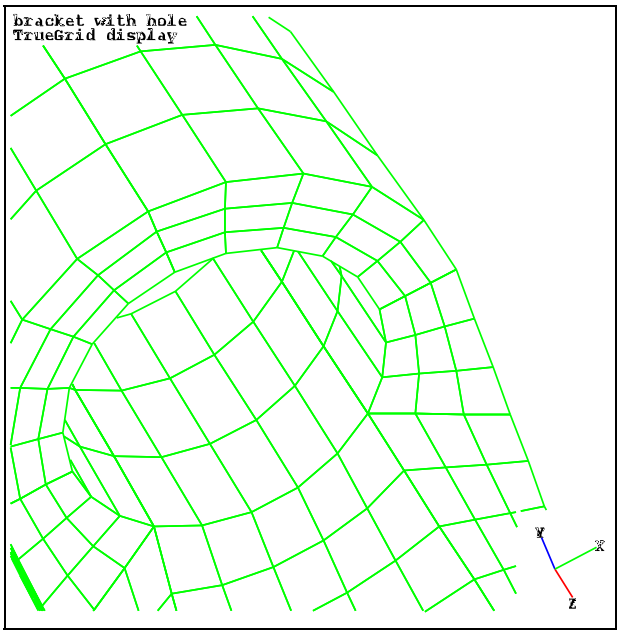


Figure 64 Zoomed Picture

Zooming the Picture

To ***Zoom*** forward or backward: press the ***Zoom*** button with the Left Mouse Button. Then perform a click-and-drag operation using the Middle Mouse Button in the window containing the picture you wish to scale. As the mouse is moved upward, a new skeleton picture is drawn that is larger than the previous. As the mouse is moved downward, a skeleton picture is drawn that is smaller than the previous. Release the mouse button to end the click-and-drag operation and to see the new picture. If the mouse is moved the entire height of the picture, the picture will be scaled by a factor of 10. **Figure 64** is created from **Figure 63** by the ***Zoom*** option (zoom out, which is down). See also: **zb**, **zf**, **dpic**, **rpic** commands.

Labels Panel - Labeling Objects

Most objects, such as parts, surfaces, 3D curves, block boundaries, surfaces edges, surface points, curve points, nodes, linear bricks, beams, linear shells, quadratic shells, and quadratic bricks are identified and

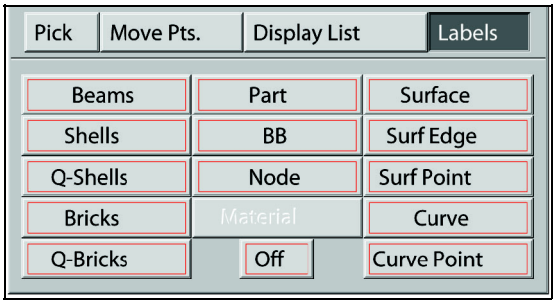


Figure 65 Labels Panel

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

referred to in commands by a unique positive number or, in some cases, several numbers separated by periods. Any of these objects that are visible in the physical window can be labeled. These objects and more can also be labeled using the **labels** command through the menu system or by issuing the **labels** command in the text window. This does not include 2D objects, such as 2D curves and load curves, since they are displayed in a separate 2D Curves window and are controlled with a different set of commands.

A labeled object can be selected by clicking on the ***Label*** button in the ***Pick*** panel and clicking on the label in the physical window. Do not confuse the ***Label*** button in the ***Pick*** panel with the ***Labels*** panel. There are many reasons to pick a label in the picture.

A labeled object can be selected for a command by clicking on the label and pressing the **F8** key. This enters the label into a command in one of two ways. If a dialogue box is present and the mouse is not located in the text window, then the label will be entered into the dialogue box. (Be sure that the correct field in the dialogue box is active with a solid green curser.) Otherwise, the label will be printed into the text window.

If a surface point or curve point is selected by its label, the point's coordinate(s) can be entered into a command in two different ways by pressing the **F7** key. If a dialogue box is present and the mouse is not located in the text window, then the coordinate(s) of the point will be entered into the dialogue box. (Be sure that the correct field(s) in the dialogue box are active with the green curser and with the first entry having a solid green curser.) Otherwise, the coordinate(s) will be printed into the text window. Note that you can choose all or a subset of the coordinates to be printed by checking the coordinates in the ***Pick*** panel.

If a region or progression of the mesh is selected (Part phase only) and a surface is selected by its label, then clicking on the ***Project*** button (not to be confused with the ***Projection*** button in the ***Pick*** panel) will project the mesh object to the surface by issuing the **sf** or **sfi** command. In a similar fashion, and clicking on any labeled surface point, curve point, curve, or surface edge and clicking on the ***Attach*** button will move the selected mesh object to that labeled object by automatically issuing the appropriate move or initialization command.

A surface, surface edge, or curve can be selected for ***Projection*** in the ***Pick*** panel (not to be confused with the ***Project*** button).

Labeled surface or curve points can be selected and their coordinates will be automatically entered into the **Point List** window for the ***LP3***, ***SPLINE***, and ***TWSURF*** interactive 3D curves.

Selected labeled surface edges are automatically entered into the ***COEDGE*** interactive 3D curve **Edge List** window which builds composite 3D curves.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Surfaces, curves, block boundaries, and parts can be selected by clicking on the labels manipulated using the ***Display List*** panel.

Labels are not allowed to overlap. Sometimes you may need to zoom in to see a label appear on the desired object. Rotating the picture may also help.

In the Part Phase, the following buttons are active in the ***Labels*** panel (the buttons that are grayed out are inactive):

Off	Remove all labels from the picture
Surface	Display labels for surfaces in the picture
Surf Point	Display labels for points on surfaces in the picture
Surf Edge	Display labels for edges of surfaces in the picture
Curve	Display labels for 3D curves in the picture
Curve Point	Display labels for points on 3D curves in the picture
Part	Display labels for parts in the picture.
BB	Display labels for block boundaries in the picture

In the Merge Phase, there are additional active buttons:

Beams	Display labels for 1D beam, bar, or truss elements in the picture. Beam elements are numbered independent of other elements, starting at 1.
Shells	Display labels for linear (3 and 4 node) 2D shell, plate, or membrane elements in the picture. Linear shell elements are numbered independent of other elements, starting at 1.
Q-Shells	Display labels for quadratic (7 or 8-node) 2D shell, plate, or membrane elements in the picture. Quadratic shell elements are numbered independent of other elements, starting at 1.
Bricks	Display labels for linear (4, 6, or 8-node) 3D solid elements in the picture. Linear brick elements are numbered independent of other elements, starting at 1.
Q-Bricks	Display labels for quadratic (10, 15, or 20-node) 3D solid elements in the picture. Quadratic brick elements are numbered independent of other elements, starting at 1.
Node	Display labels for numbered nodes in the picture. The node numbers reflect any merging of nodes.

Also refer to: **labels** command (see pg.300)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 66 was created by options ***Labels*** (***Surface***), ***Display List***, ***Surface*** (***Show All***) and ***Hide***, ***Draw*** from the Environment Window. Alternatively, you can type **dasd**; **labels sd**; **disp**.

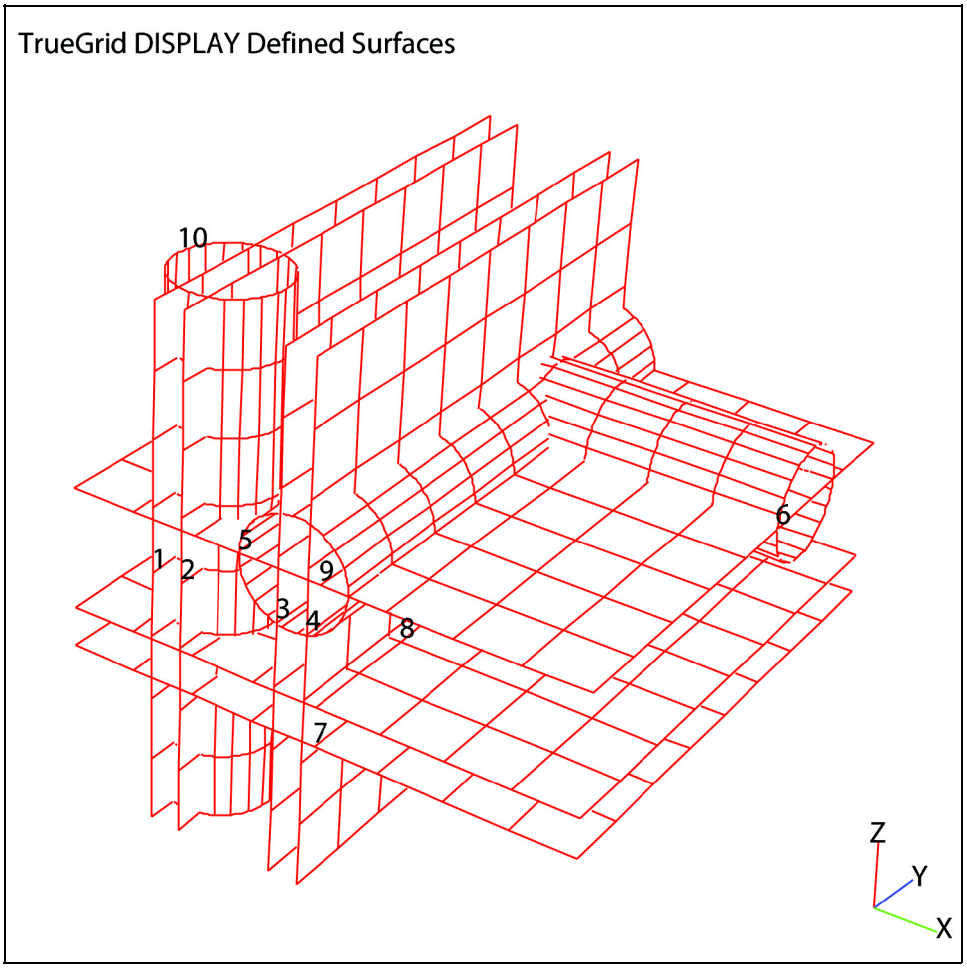


Figure 66 Surfaces are labeled

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 67 was created by options ***Labels*** (***Surf Point***), ***Display List***, ***Surface*** (***Show All***) and ***Hide***, ***Draw*** from the Environment Window. Alternatively, you can type **labels sdpt**; **dasd**; **disp**.

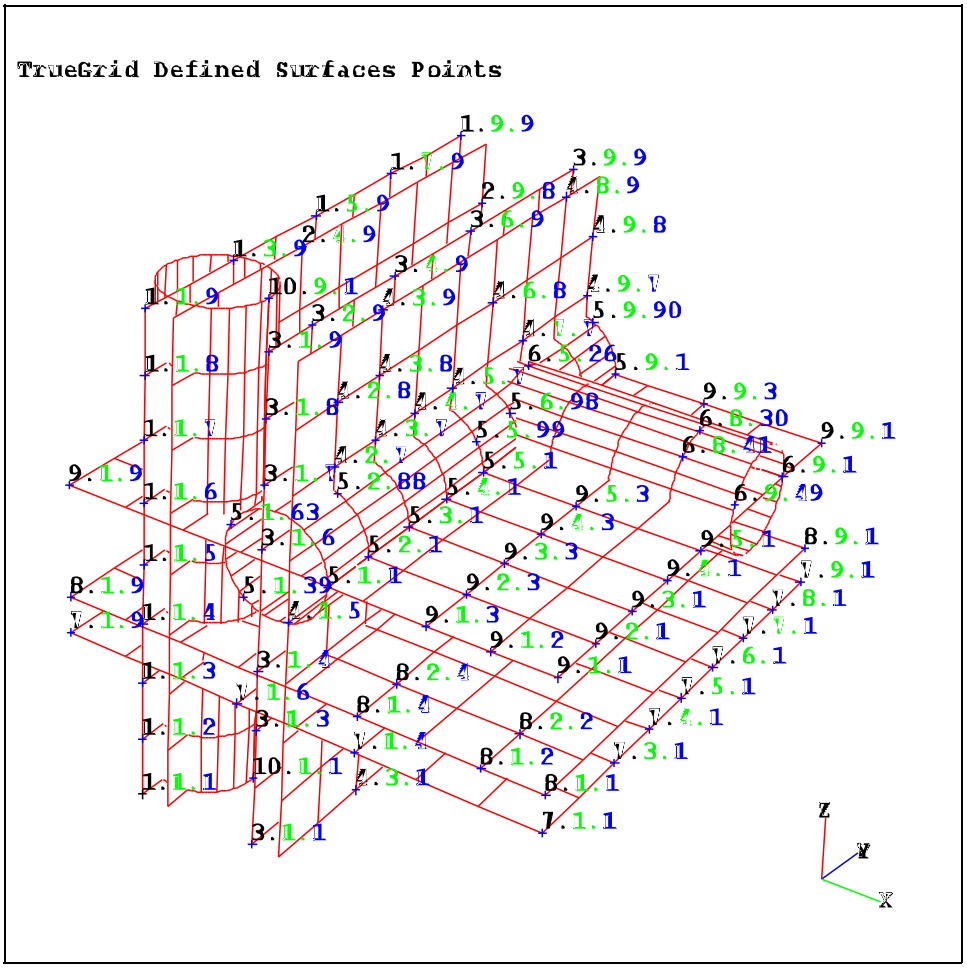


Figure 67 Surface Points are labeled

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 68 was created by options ***Labels*** (***Curve Point***) and ***Display List***, ***Curve*** (***Show All***) from the Environment Window. Alternatively, you can type **labels crvpt**; **dacd**.

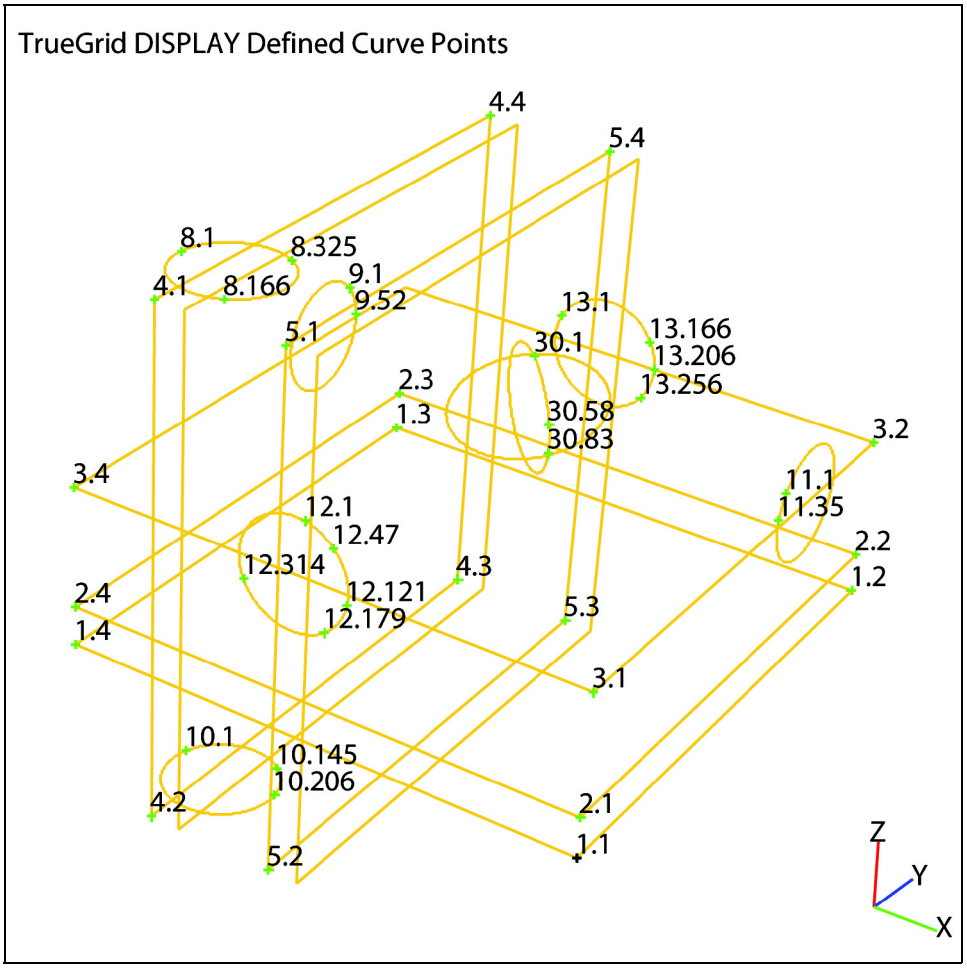


Figure 68 Curve Points Labels

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 69 was created by options ***Labels*** (***Part***) and ***Display List***, ***Part*** (***Show All***) from the Environment Window. Alternatively, you can type **labels parts**; **dap**; **disp**.

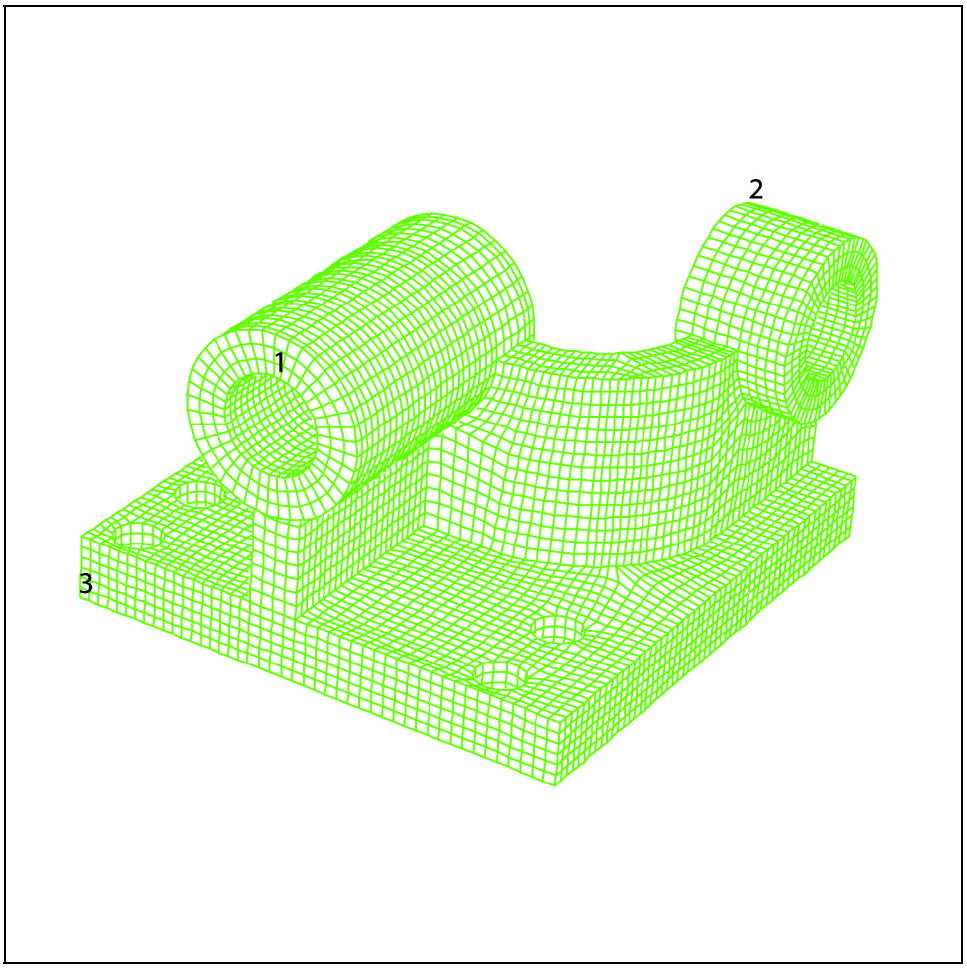


Figure 69 Part Labels

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 70 was created by options ***Labels*** (***Node***) and ***Display List***, ***Part*** (***Show All***) from the Environment Window. Alternatively, you can type **labels nodes**; **dap**; **disp**.

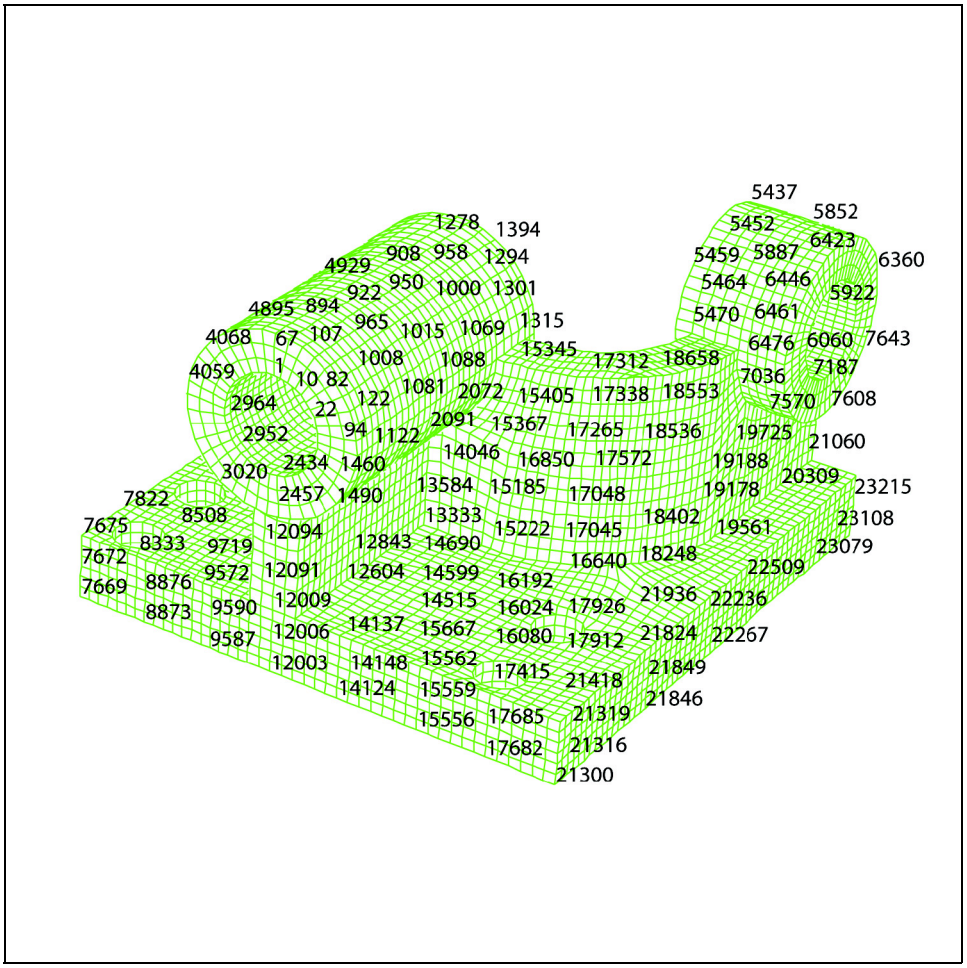


Figure 70 Node Labels

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 71 was created by options ***Labels*** (***Brick***) and ***Display List***, ***Part*** (***Show All***) from the Environment Window. Alternatively, you can type **labels 3d**; **dap**; **disp**.

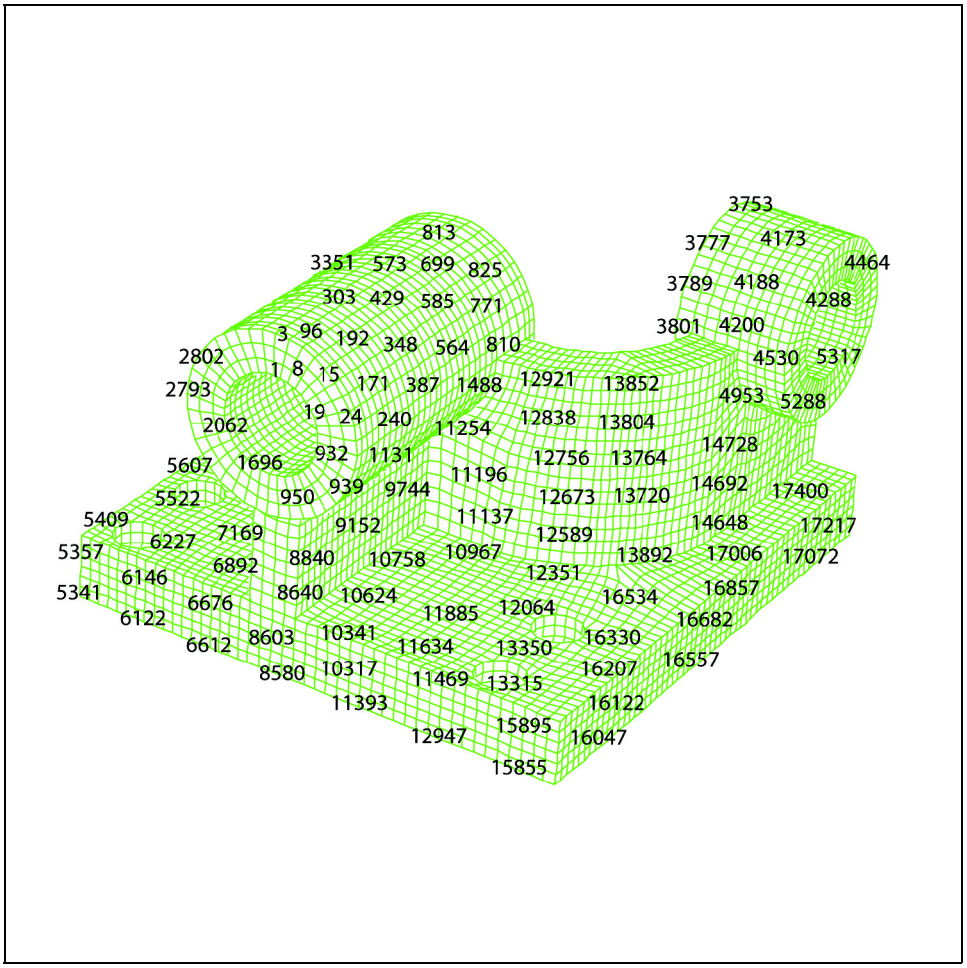


Figure 71 Brick Labels

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Pick Panel - Pick an Object

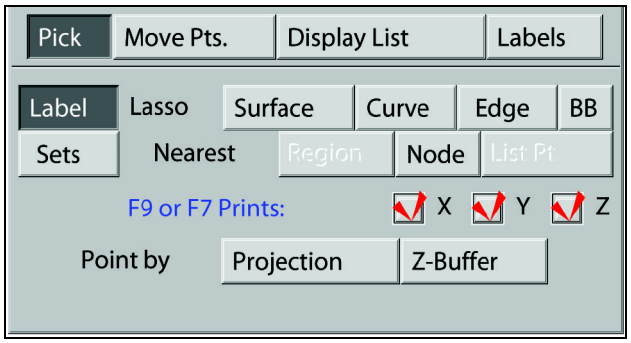


Figure 72 Pick Panel

A object, such as a surface, curve, surface edge, or block boundary, can be selected using the mouse to select for the ***Display List***, or to project or attach a portion of the mesh. In order to select an object referenced by a label, first press one of the buttons described above to display labels for the type of object in which you are interested. Next, select the ***Pick*** panel in the Environment Window, and select the (Pick Object by) ***Label*** button. Press the Left Mouse Button on a label in the picture, and the object referenced by the label will be highlighted. Pressing the Left Mouse Button on the same label again will turn off the highlighting; pressing the Left Mouse Button on another label will turn off the highlighting for the first and highlight the second.

Alternatively, go to the ***Pick*** panel, select either ***surface***, ***curve, edge***, or ***BB***. Click the mouse button in the Show field and type the label of the geometric object. Then click on the ***Show*** button or hit return in order to see that object highlighted.

Pick Objects with a Lasso

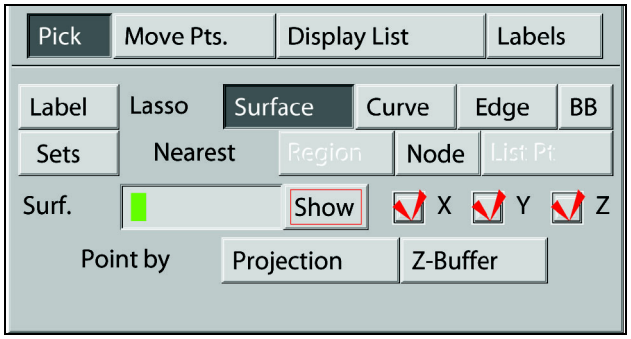


Figure 73 Show button in the pick panel

Select the type of geometric object in the ***Pick*** panel. Then with the Left Mouse Button in the Physical Window, click-and-drag to create the diagonal of a rectangular box. The box will be overlaid in white. When the Left Mouse Button is released, all objects of the selected type with some portion in the rectangular box, will be highlighted. If only one object is selected, its label will appear in the show field (within the Environment Window). If more than one is captured with the lasso, then the word "many" will appear in the show field.

In the pictures that follow, the surfaces are displayed by the ***Surfaces*** and ***Show All*** options from the ***Display List*** panel. The ***Pick*** panel is activated and the option ***Surfaces*** is selected. Then the mouse is moved into the Physical Window and a lasso is created (**Figure 74**). The selected surfaces are highlighted (black) (**Figure 75**) and the edges are labeled. The ***Pick*** panel is activated and the option ***Edges*** is selected. Then the mouse is moved into the Physical Window and a lasso is created (**Figure 76**). **Figure 77** shows the resulting highlighted edges (blue). The described technique is good for extraction of the objects of interest.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

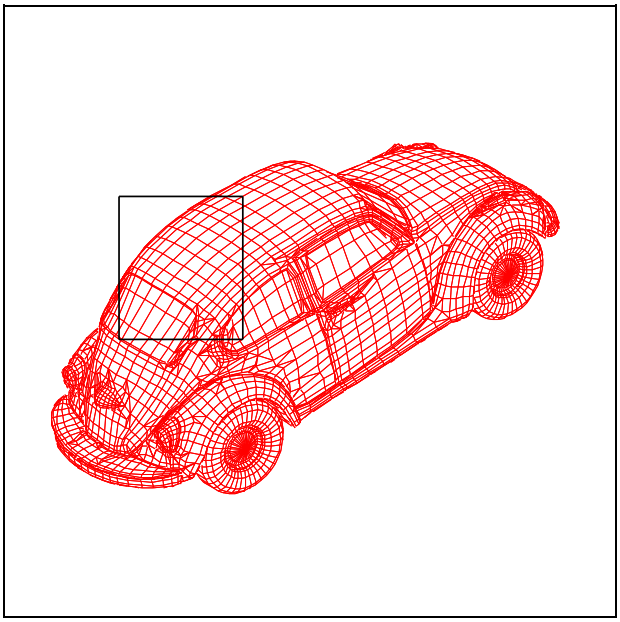


Figure 74 Lasso for Surfaces

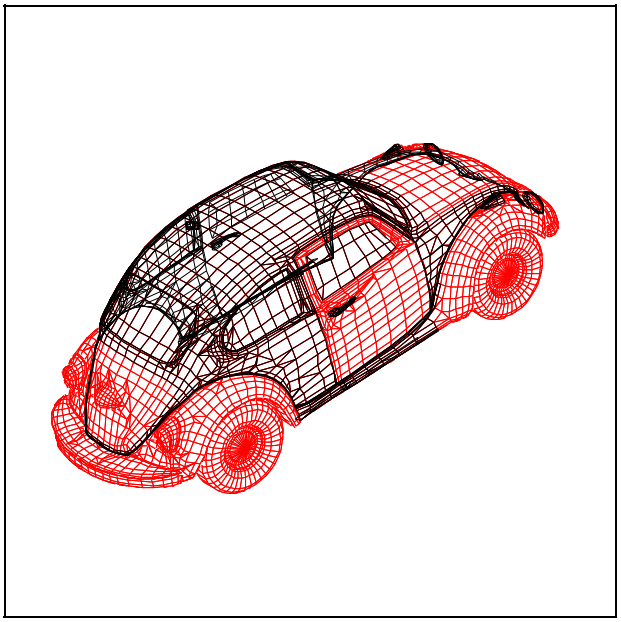


Figure 75 Highlighted Surfaces

Figure 76 Lasso for Edges

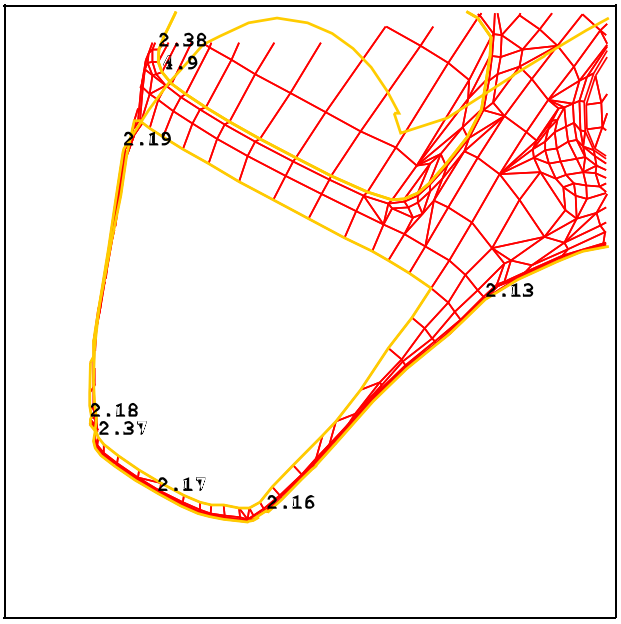


Figure 77 Highlighted Edges

Coordinate System of a Picked Point

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

When a point is picked using the mouse, in all of the various ways, the coordinates are displayed at the bottom of the ***Pick*** panel. They are usually in the global coordinate system. When you are generating a part using the cylinder part command, the coordinates can be in the global system or in the local coordinate system being used by the cylinder part. You can choose by clicking on the ***Global*** or ***Local*** button in the ***Pick*** panel. The local option is only available when creating a cylinder type part.

Pick Panel - Picking a Point by Projection

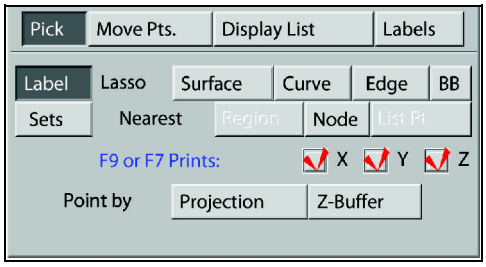


Figure 78 Pick Panel

A point can be picked with the mouse by projection onto a surface, curve, or a surface edge (**Figure 78**). The surface, curve, or surface edge must be picked first. You can select these geometrical objects either by lasso or by label. At this point, the bottom of the pick panel will show the subject of the projection. Then click the ***Projection*** button (Be careful, not the ***Project*** button!) and select the point by clicking the Left Mouse Button in the desired location on the screen.

The results of the Pick by Projection operation are x,y,z coordinates of the point, which is positioned on the aforementioned surface, curve or surface edge. Once selected, the x,y,z coordinates can be entered into a dialog box by pressing **F7** or **F9** (when the cursor is over the dialog box). This method is not appropriate to use with folded surfaces or surfaces with large curvature. The Pick by Projection operation can be used in ***Wire***, ***Hide*** or ***Fill*** modes.

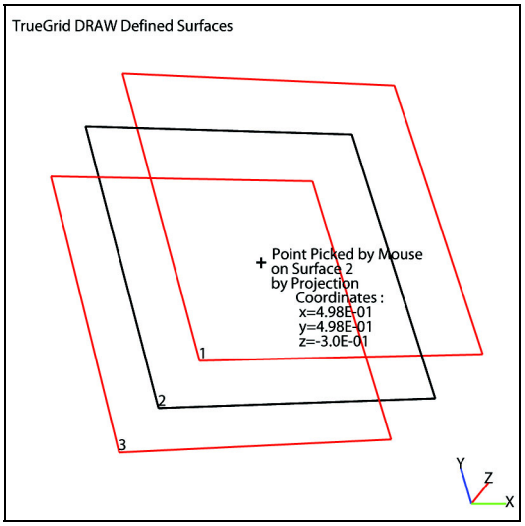


Figure 79 Point picked by Projection

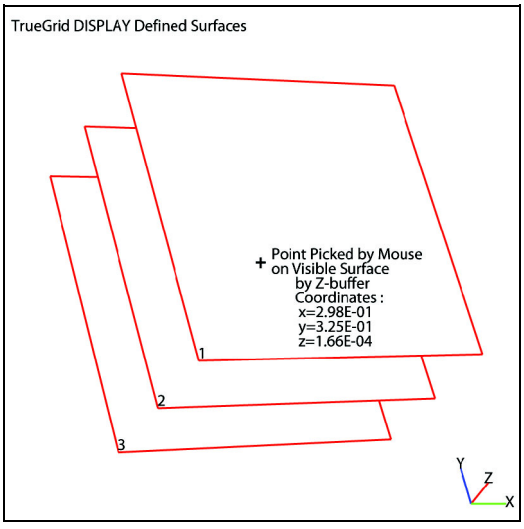


Figure 80 Point picked by Z-buffer

Pick Panel - Pick a Point by Z-buffer

A point can be picked by ***Z-Buffer*** on a visible surface, shell face, or brick face in the ***Hide*** or ***Fill*** mode (**Figure 80**). The point is picked by clicking the Left Mouse Button in the desired location on the screen. The resulting

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

x,y,z coordinates can be filled into the dialog box by pressing **F7** or **F9**. The Z-buffer algorithm selects the point where the mouse is located on the visible object. If the mouse is clicked where there is no object, then the x,y,z coordinates are extracted from the back plane.

Pick Panel - Picking a Node

There are three methods to select a node in the physical window. The first method requires labeling the nodes in the ***Labels*** panel. This is only possible in the merge phase. The choose ***Label*** in the ***Pick*** panel. When you click on a label of a node in the physical window, you are selecting the associated node.

You can also click on the ***Node*** button in the ***Pick*** panel. Then click on any node to select it. Notice that the indices of the node (in the part phase) or the node number (in the merge phase) are shown in the ***Show*** field of the ***Pick*** panel. Alternatively, you can enter the indices of a node (in the part phase) or the node number (in the merge phase) and click on the ***Show*** button to select that node.

You can also select a node forming a block boundary interface showing in the picture by clicking on the node.

Pick Panel - Picking a Vertex

True*Grid*® has two types of mesh objects that can be selected using the mouse. These selected portions of the mesh can be used for various reasons. For example, you can select a region of the mesh and then invoke the history window to see all of the commands applied to the selected region. This coupling of the history and physical window is important when you have a complex problem with an error in your input. The history window can be used to find the command(s) in error and to correct the error(s). The history window is you primary tool in debugging your mesh.

The two types of mesh objects are Regions and Index Progressions. Please note that the ability to make these types of selections in the mesh are available only in the part phase because the block structure of the part (or its topology) is only known while in the part phase.

A **Region** is described by six numbers, the minimum and maximum values for each of the three reduced indices (reduced indices are described in the introduction). Thus, a region can be anything that is "rectangular" in computational space: a vertex of the mesh, an edge of the mesh, a face of the mesh, or a prism shaped volume or block in the mesh.

An **Index Progression** can be any part of the mesh that you can select with the mouse in the Computational Window. An index progression might describe one region or many regions. For example, all six faces of a cube can be described by one index progression. A complex index progression cannot be selected using the physical window. A complex index progression is one which

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

cannot be described by a single region description. See the description of the computational window for selecting complex index progression. Index progressions are mentioned in this section for completeness.

By using your mouse, you can highlight a portion of the physical or computational mesh and select that portion as input for a command. The distinction between Regions and Index Progressions is noteworthy because some **True*Grid*®** commands apply to Regions and others apply to Index Progressions. Often a command comes in two versions, one for Regions (e.g. **sf**) and the other for Progressions (e.g. **sfi**). An "i" at the end of a command name generally indicates that it is applied to Index Progressions.

There are actually four different techniques using the mouse to select a Region or Index Progression. Each technique has its advantages. It is best to become proficient in all four techniques so that you can easily select objects of the mesh. You will need to do this many times in the process of creating a mesh. The four methods are:

1. Index bars
2. Click-and-drag in the computational window
3. Function keys **F5** and **F6** in the physical window
4. Pick Region and click-and-drag in the physical window

This section of the manual discusses only the last two methods which involve the physical window. See the section on the computational window to learn how to select objects in the mesh from the computational window.

To highlight the Vertex which is closest to the mouse, first press the ***Pick*** button in the Environment Window. Then click on the ***Region*** button. Now click the Left Mouse Button in the Physical Window. The nearest vertex to the mouse will be highlighted in red, and the corresponding computational vertex will also be highlighted. Click the Left Mouse Button again to choose another vertex. The same thing can be accomplished by hitting the **F5** key when the mouse is close to the vertex.

In the following pictures, the block partitions are shown in heavy lines. This is done for emphasis. These heavier lines do not actually appear as such on the monitor. The part used in this example has two blocks in each direction. It was created with the command:

```
block 1 3 5;1 3 5;1 3 5;0 .1 .2;0 .1 .2;0 .1 .2;
```

The mouse and a mesh are shown in **Figure 81**. The closest vertex to the mouse is highlighted in **Figure 82**. This method highlights vertices as opposed to nodes. (Vertices lie at the intersection of 3 partitions.)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

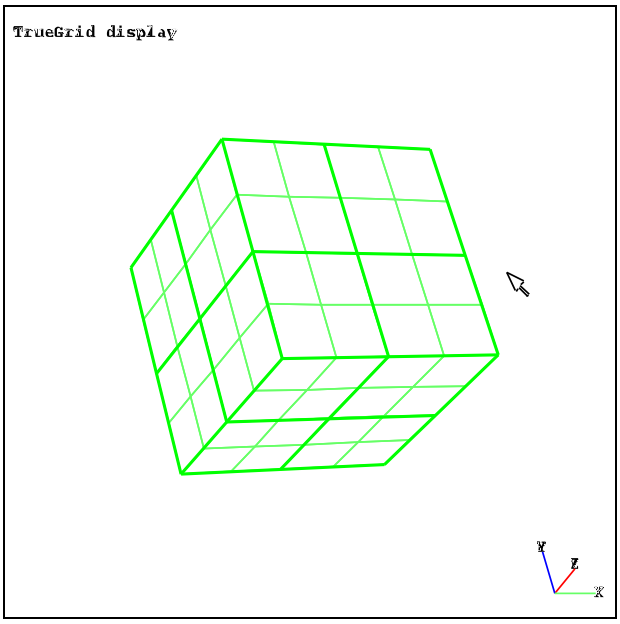


Figure 81 Before Clicking Left Mouse Button

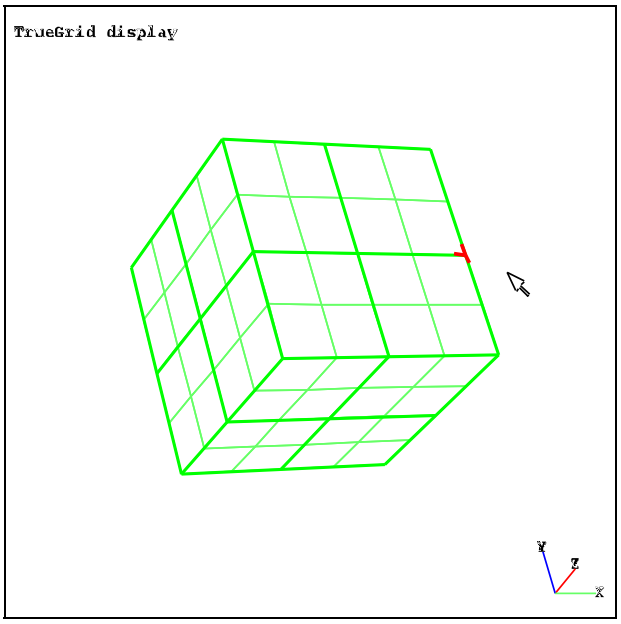


Figure 82 After Clicking Left Mouse Button

Pick Panel - Picking Partial Coordinates

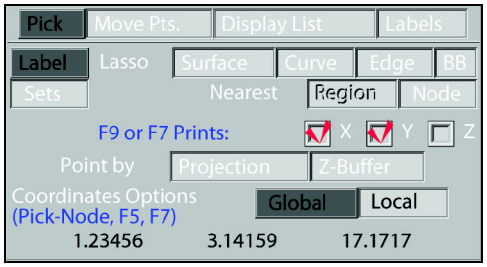


Figure 83 Z-coordinate inactive

In some situations, you may wish to only use one or two of the coordinates picked by ***Label***, ***Projection***, ***Z-Buffer***, ***Region***, or ***Node***. For example, you may wish to move an edge of the mesh so that all nodes along the edge are given the same x and y-coordinates, leaving the z-coordinate of each node unaltered. This can be done in the ***Pick*** panel by clicking the check in the box next to the Z. If you click in the box again, then the check will reappear. Each coordinate can be made active or inactive independently of the other coordinates. Whenever the **F7** key is used, only the checked coordinates will be printed. When the ***Attach*** button is clicked, only the checked coordinates of a point are used to make an attach. The inactive coordinates have no affect on attaching to a curve or surface edge.

The picked coordinates are shown at the bottom of the Pick panel.

Pick Panel - Picking an Edge, Face, or Block

When ***Region*** button is selected in the ***Pick*** panel, then one can select any region in the Physical

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Window.

Click-and-drag with the Left Mouse Button from one end point of an edge of the mesh to the other endpoint of the edge (**Figure 84** and **Figure 85**). The edge will turn blue as you do this (**Figure 86** and **Figure 87**).

If the mouse is dragged, instead, to the opposite corner of a face of the mesh, then that face will be selected and highlighted in yellow (**Figure 88** and **Figure 89**).

If the mouse is dragged to the opposite corner of a block, then the whole block will be selected and highlighted in cyan (**Figure 90** and **Figure 91**).

As long as the Left Mouse Button is depressed, you can continue to drag the mouse and highlight objects in the mesh. Release the Left Mouse Button only when the highlighted object is what you want.

The same thing can be accomplished by first selecting one vertex with the **F5** key, described above. Then move the mouse close to the opposite corner of the desired region and hit the **F6** key.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

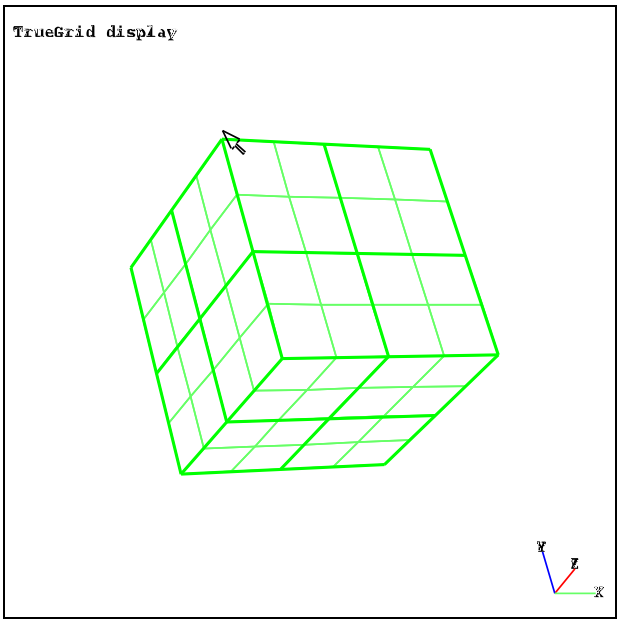


Figure 84 Step 1 : Move to a vertex

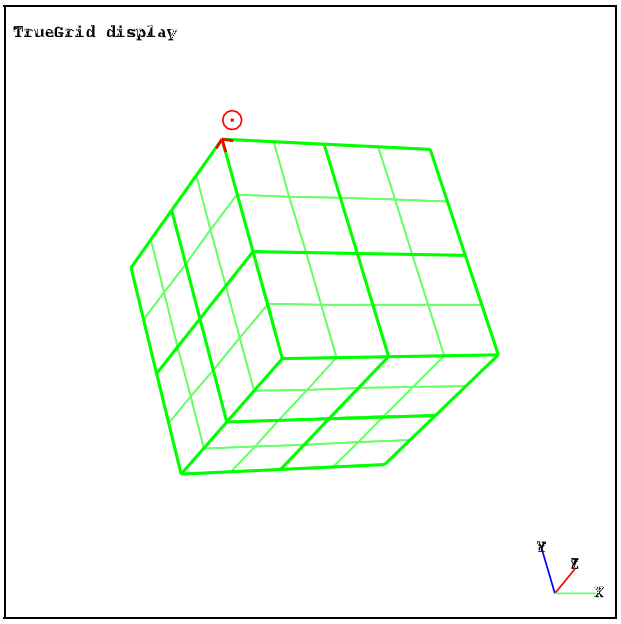


Figure 85 Step 2 : Hold down left button

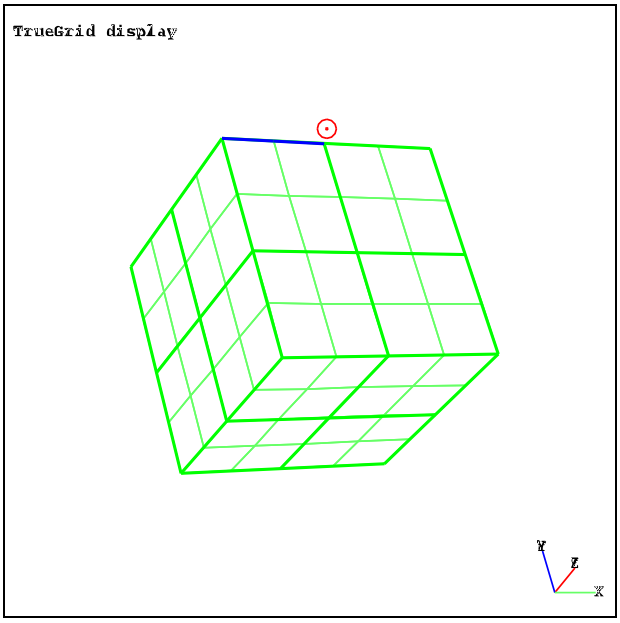


Figure 86 Step 3 : Drag mouse

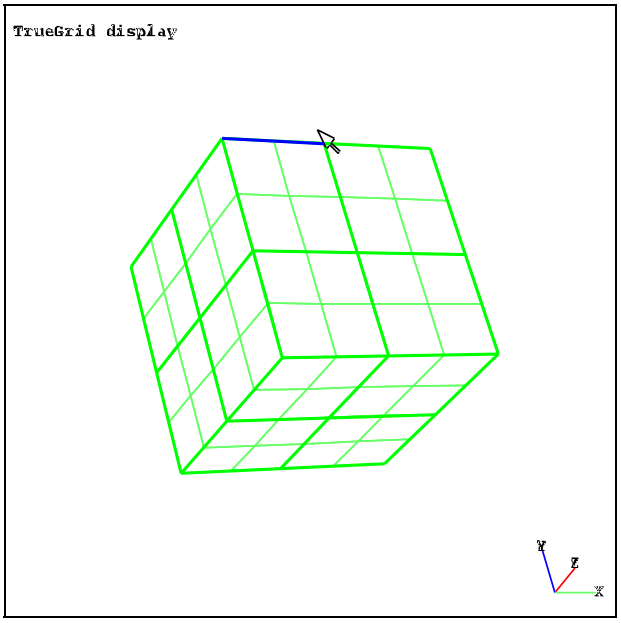


Figure 87 Step 4 : Release button

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

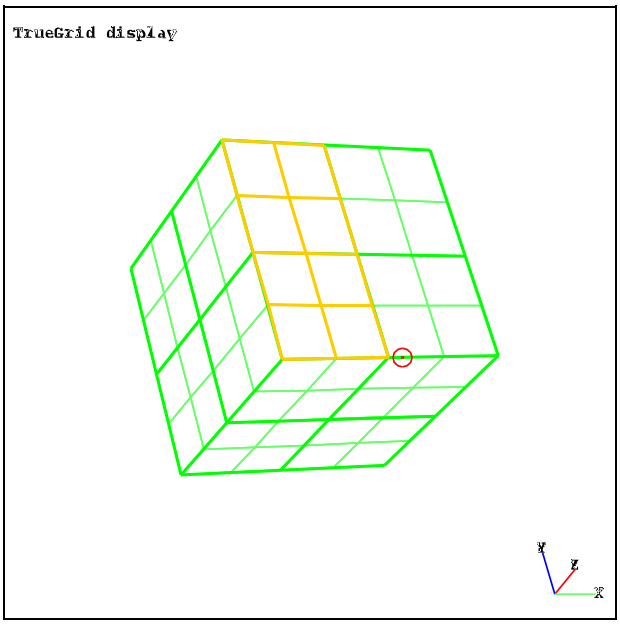


Figure 88 Alternate Step 3 : Drag mouse

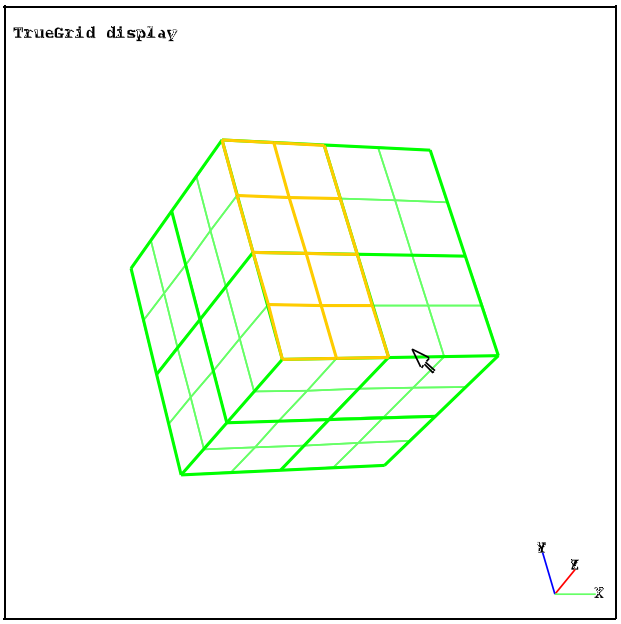


Figure 89 Step 4 : Release button

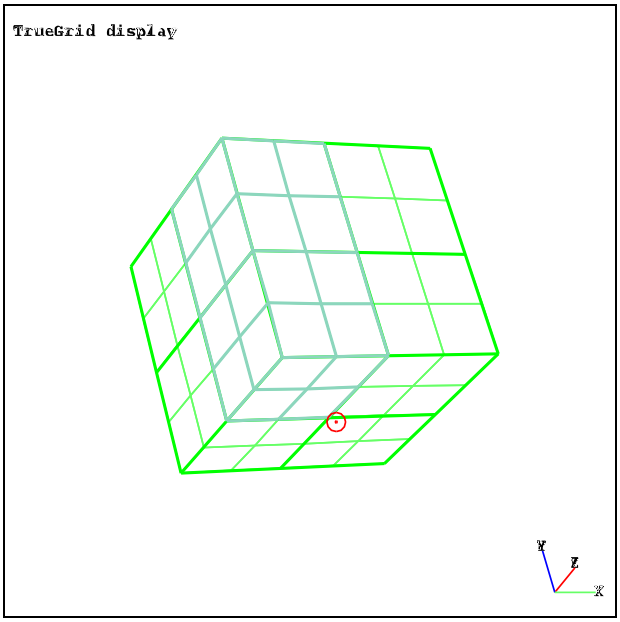


Figure 90 Alternate Step 3 : Drag mouse

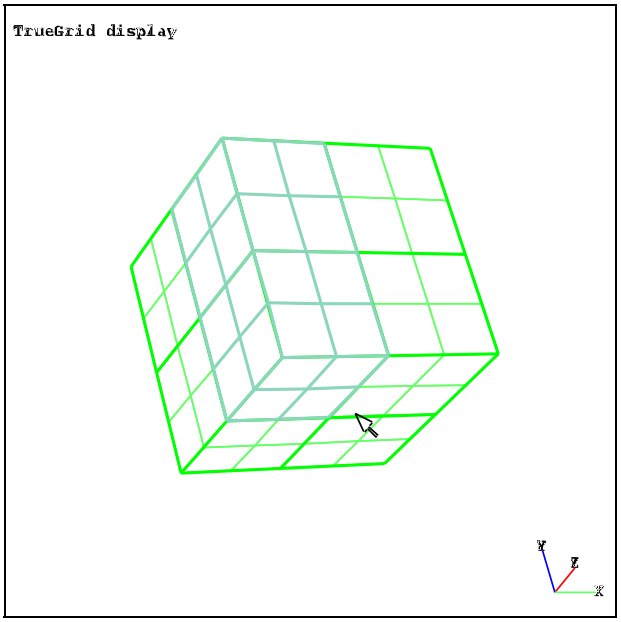


Figure 91 Step 4 : Release button

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Pick Panel - Creating or Modifying Sets Using the Mouse

There are 3 ways to create a set. While in the part phase or the merge phase, you can use the **nset** command to create or modify a node set, the **fset** command to create or modify a face set, and the **eset** command to create or modify an element set.. The selections made in the part phase are parametric because they reference edges, faces, and blocks of the mesh. The mesh densities or the geometry can be modified without effecting the set selections. The selections made in the merge phase using these commands can also be parametric, based on geometric objects.

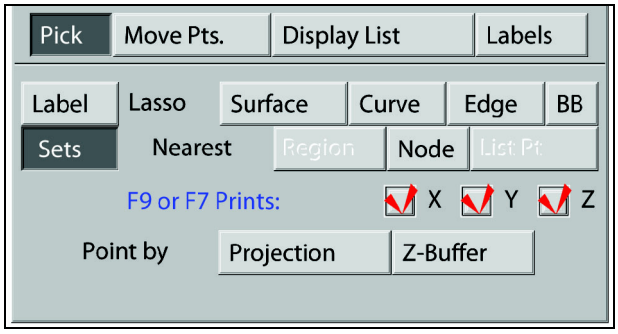


Figure 92 Pick Sets

In contrast, this section discusses the use of the mouse to create or modify sets of nodes, faces, elements, and surface polygons. This is in contrast with the **nset**, **fset**, and **eset** commands because the selections made with a mouse are not parametric. If the mesh is modified, such as changing the mesh density, the set selections made using the mouse must be scrapped and new selections made. For completeness, it should be mentioned that there is also a **pset** command for selecting surface polygons and available only in the merge phase.

In order to select a set, first depress the ***Pick*** button of the Environment Window and select the ***Sets*** option (**Figure 92**). The Set Editing window will appear. This option is only available in the Merge Phase. The Set Editing window is used for the interactive creation or modification of node, face, element, and surface polygon sets. Face sets consist of both brick faces and shells. Element sets can consist of all types of elements.

Control Options:

Quit	Quit the Sets Window.
Open Set	Activate an existing Set. When you open a set, you load its contents into the set buffer. It will be displayed as if you had just made selections using the mouse. Nodes, faces, and element sets are named independently. It is possible to have a set of each type with the same name. For this reason, be sure to select the type of object that you wish to operate on in the set window before you open a set.
Save As	Save the Active Set. After you select some objects to form a set or after you have modified the selections from a set that you have opened, you must save it for your selections to become effective. If you are modifying an element set, then clicking on the Save button only saves or replaces the elements of the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

selected type.

Selection Options:

Nodes	Node sets will be modified.
Faces	Face sets will be modified.
Beams	Subset of Beam elements of an element set will be modified.
Shells	Subset of Linear Shell elements of an element set will be modified.
Q-Shells	Subset of Quadratic Shell elements of an element set will be modified.
Bricks	Subset of Linear Brick elements of an element set will be modified.
Q-Bricks	Subset of Quadratic Brick elements of an set will be modified.
Polygons	Create a polygon set from polygon type surfaces. These sets can be turned into new polygon surfaces.

Set Editing Options:

Add	Add selected items to the Active Set.
Remove	Remove selected items from the Active Set.
Toggle	Change the status of the selected items. The selected items belonging to the Active Set are removed from the Active Set. The selected items not belonging to the Active Set are added.
Clear	Clear the last selection. If you do not clear the set selection before you close the set window, then the next time you activate the set window, the same objects will be in the set buffer so that you can continue your set operations from where you left off.

Nodes Required to Select:

1	Faces, beams, shells or bricks with one node belonging to the selected area are selected.
2	Faces, beams, shells or bricks with two nodes belonging to the selected area are selected.
3	Faces, shells or bricks with three nodes belonging to the selected area are selected.
4	Faces, shells or bricks with four nodes belonging to the selected area are selected. Three node shells can be selected with this option too.
5-8	Bricks with this number of nodes belonging to the selected area are selected.
Mid	Faces, beams, or shells with mid node belonging to the selected area are selected.

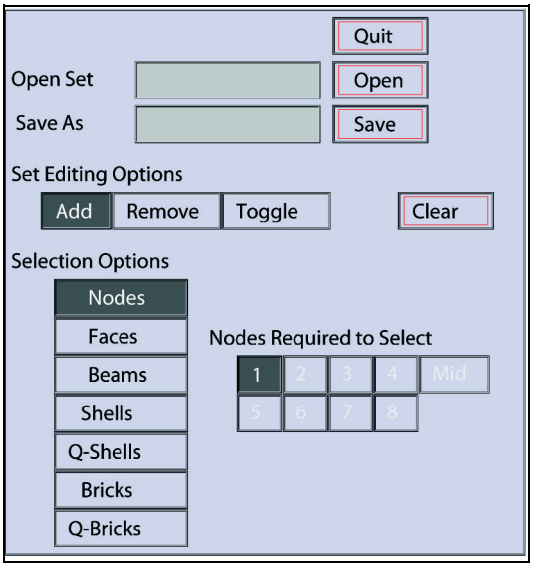


Figure 93 Sets Window

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

How to Create a Node Set

Select ***Pick*** and ***Sets*** in the Environment Window. The ***Nodes*** option is selected (**Figure 93**). Move the mouse to the Physical Window. Depress the Left Mouse Button and draw a curve around the nodes you want to select while continuing to hold the Left Mouse Button. Release the Left Mouse Button and the curve is automatically closed by a straight line segment between endpoints. The enclosed area turns white and the selected nodes are identified.

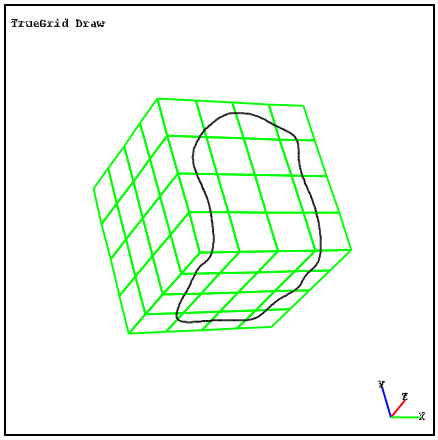


Figure 94 Selection Curve

The selection is based on visible nodes, so you can change your selection by changing to a different display mode (***Wire***, ***Hide***, ***Fill***). The selected nodes are identified by squares (**Figure 95**).

You can modify the set by adding, removing, and toggling nodes (***Add***, ***Remove***, ***Toggle*** options). You can save the active set by typing its name in the save window and hitting the ***Save*** button.

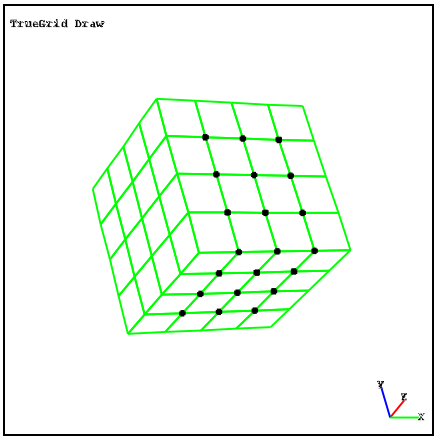


Figure 95 Marked Node Set

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

How to Create a Face Set

Select ***Pick*** and ***Sets*** in the Environment Window. Then, in the Sets Window, select the ***Faces*** option (**Figure 96**).

Move the mouse to the Physical Window. Draw a curve around the faces you want to select while holding the Left Mouse Button (**Figure 97**). Release the Left Mouse Button and the curve is automatically closed by a straight line segment between endpoints.

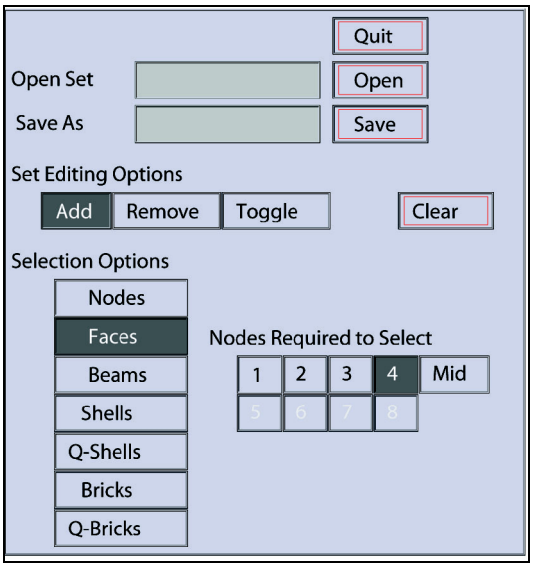


Figure 96 Sets Window

The enclosed area turns white and the selected faces are identified by crosses (**Figure 98**).

The selection is based on visible nodes, so you can achieve various effects by setting different display modes (***Wire***, ***Hide***, or ***Fill***).

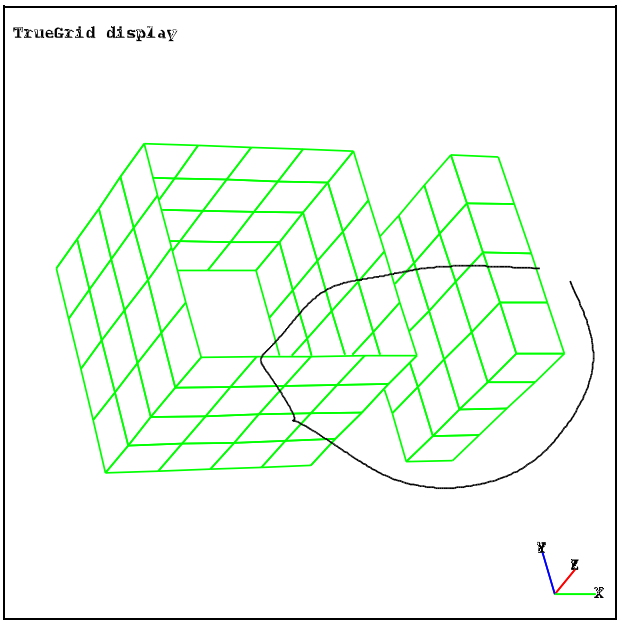


Figure 97 Selection Curve

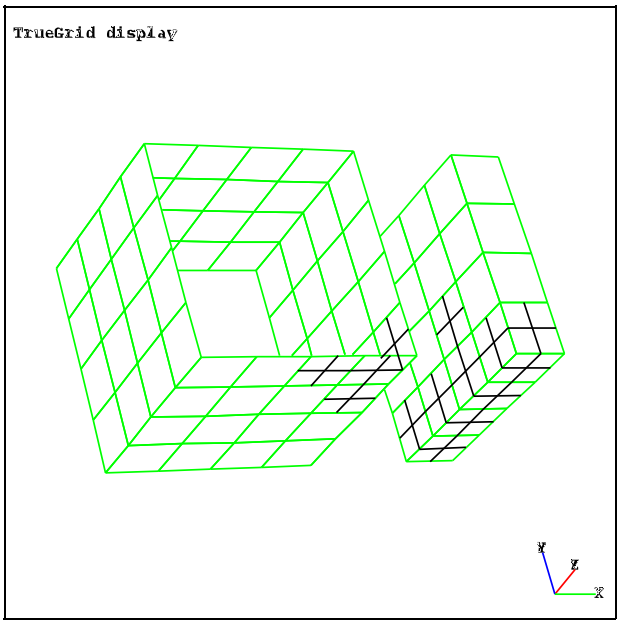


Figure 98 Face Set is Marked

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

You can modify the active face set by adding, removing and toggling faces (***Add***, ***Remove***, ***Toggle*** options). After editing you can save the active set by typing its name and hitting the ***Save*** button.

A face can originate from a linear or quadratic shell or brick. The orientation of the face can be controlled using the **orpt** command prior to saving the face set. You can also use the **fset** and **fseti** commands in the Part Phase or the **fset** command in the Merge Phase to construct or modify a face set. This is three different ways to construct face sets and when used together can be very powerful. There are advantages and disadvantages to using the **fset** or **fseti** commands in the Part Phase verses using this interactive tool or the **fset** command in the Merge Phase. The Part Phase gives you a structured parametric method for selecting a face set. If the mesh density of the part is changed or if additional parts are added to the model, the selection of the face set is unaffected. However, the Part Phase selection of faces is limited to those faces that form block regions. Also, when a part is duplicated, so is the selection of the faces for a set. If you use the Merge Phase features to select face sets, you no longer have the parametric features. If the size of the mesh changes, then the numbering of faces changes and you must create a new list of faces.

How to Create a Beam Element Set

Select ***Pick*** and ***Sets*** in the Environment Window. Then, in the Sets Window, select the ***Beams*** option . Check the number of nodes needed in the selection process. With the left mouse button pressed, circle the beams of interest. Be sure to save the set of beams.

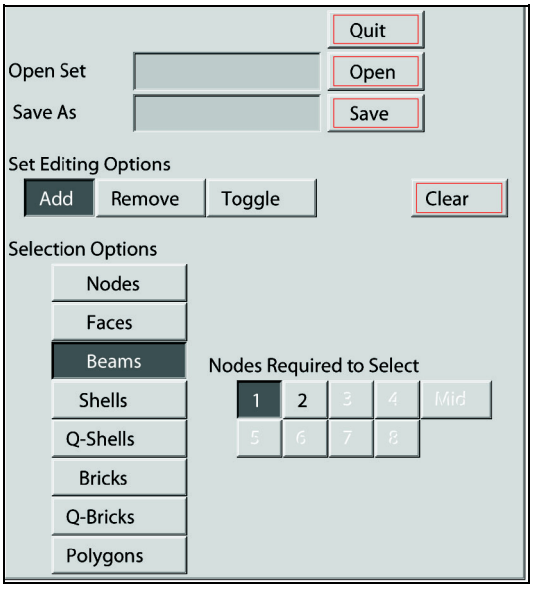


Figure 99 Sets Window - Beams

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

How to Create a Shell Element Set

Select ***Pick*** and ***Sets*** in the Environment Window. Then, in the Sets Window, select the ***Shells*** option (**Figure 100**). Check the number of nodes needed in the selection process or select the ***Mid*** option. If you choose ***1***, ***2***, ***3***, or ***4***, then a shell element will be selected only if that number of its nodes are found within the lasso region. If you choose the ***Mid*** option, then only those shell elements with midpoints in the lasso region will be selected.

Move the mouse to the Physical Window. Draw a curve around the shells you want to select while holding the Left Mouse Button (**Figure 101**). Release the Left Mouse Button and the curve is automatically closed by a straight line segment between endpoints. The enclosed area turns white and the selected shells are identified by crosses (**Figure 102**).

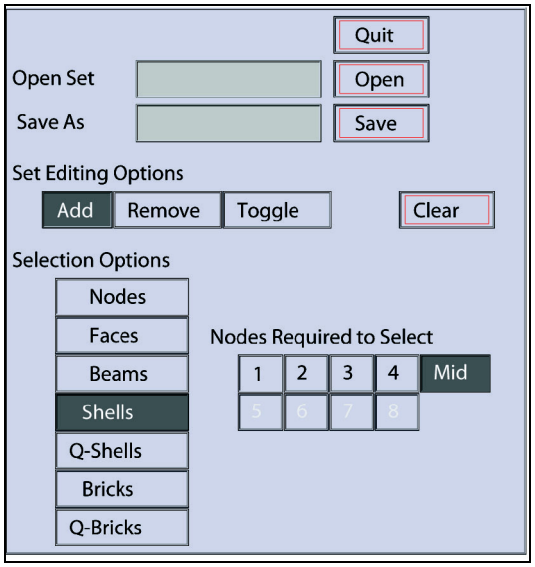


Figure 100 Sets Window - Shells

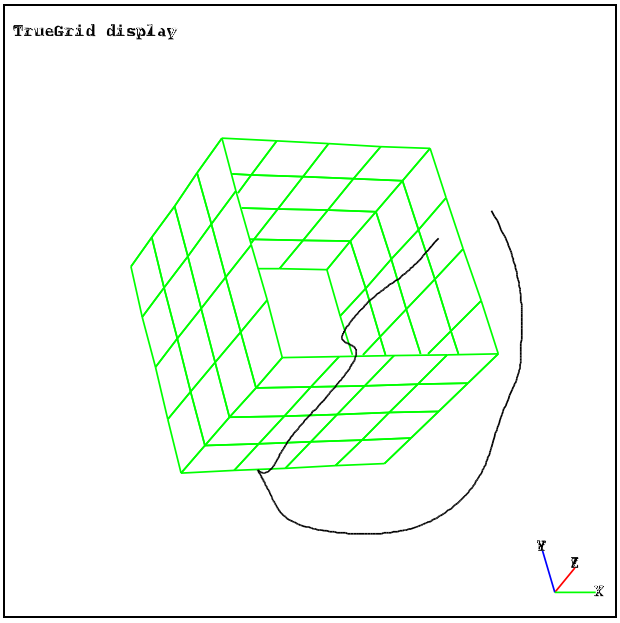


Figure 101 Selection Curve by 2 Nodes

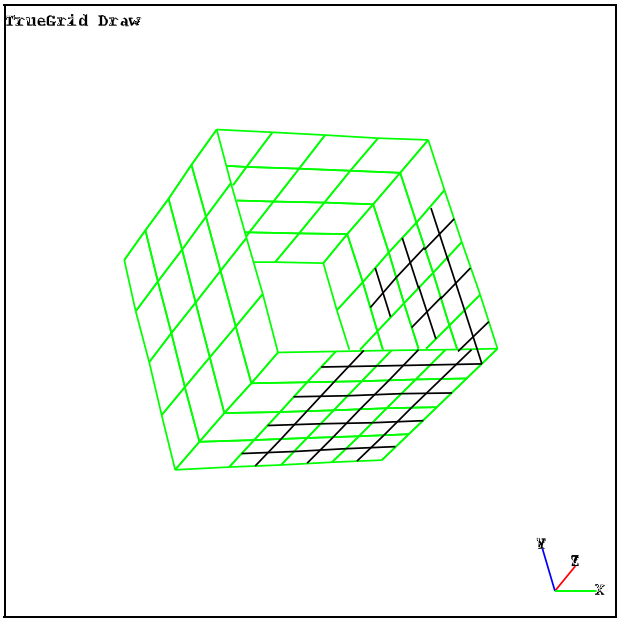


Figure 102 Shell Set is Marked

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The selection is based on visible nodes, so you can achieve various effects by setting different display modes (***Wire***, ***Hide, Fill***).You can modify the active shell set by adding, removing and toggling shells (***Add***, ***Remove***, ***Toggle*** options). For example, if you have a complex model, first restrict the parts and/or materials to those containing the elements of interest. Then draw the picture in hide or fill. Choose to select with 3 or 4 nodes. If you use 1 or 2 nodes, you may be selecting shells that may not be visible. This may be useful in some cases. Then you may have to remove some elements. Use the 1 node selection mode and draw the picture in wire mode. Click on the ***Remove*** button. Then circle a single node from a shell element you want removed. Be sure that this node is not connected to elements you wish to keep. There are many variations to this technique which you will develop as the need arises.

After editing, you can save the active set by typing its name and hitting the ***Save*** button.

How to Create a Surface Polygon Set

Surface polygon sets are useful when using complex polygon surfaces. Sometimes it is necessary for the projection method that a single surface be split into several surfaces. This is true when there is a fold in the surfaces or when two portions of a single polygon surface meet orthogonally. The splitting of a surface is done in two steps. The first step is to create a surface polygon set. The second step is to define a new polygon surface using the **sd** command and the polygon set.

Select ***Pick*** and ***Sets*** in the Environment Window. Then, in the Sets Window, select the ***Shells*** option. Check the number of nodes needed in the selection process or select the ***Mid*** option. If you choose ***1***, ***2***, ***3***, or ***4***, then a surface polygon will be selected only if that number of its nodes are found within the lasso region. If you choose the ***Mid*** option, then only those polygons with midpoints in the lasso region will be selected.

Move the mouse to the Physical Window. Draw a curve around the polygons you want to select while holding the Left Mouse Button. Release the Left Mouse Button and the curve is automatically closed by a straight line segment between endpoints. The enclosed area turns white and the selected polygons are identified by crosses.

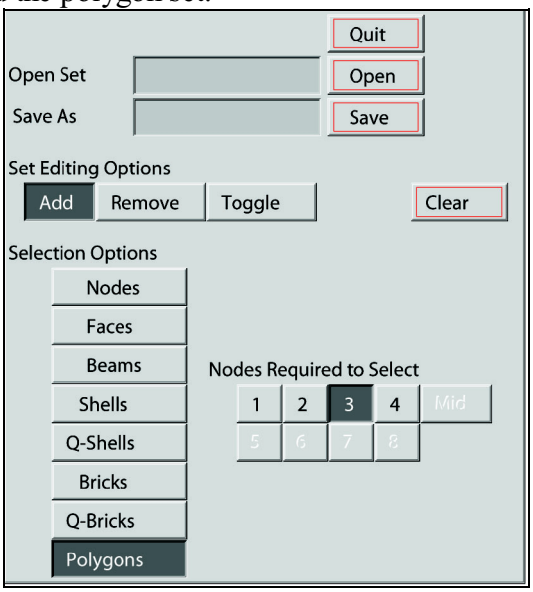


Figure 103 Sets Window - Polygons

The selection is based on visible nodes, so you can achieve various effects by setting different display modes (***Wire***, ***Hide, Fill***).You can modify the polygon set by adding, removing and toggling polygons (***Add***, ***Remove***, ***Toggle*** options). Draw the picture in hide or fill. Choose to select with 3 or 4 nodes.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

If you use 1 or 2 nodes, you may be selecting polygons that may not be visible. This may be useful in some cases. Then you may have to remove some polygons. Use the 1 node selection mode and draw the picture in wire mode. Click on the ***Remove*** button. Then circle a single node from a polygon you want removed. Be sure that this node is not connected to polygons you wish to keep. There are many variations to this technique which you will develop as the need arises.

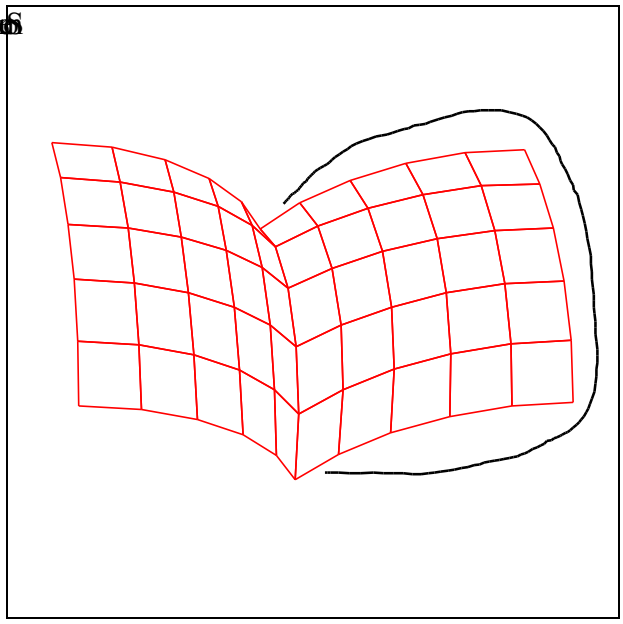


Figure 105 Polygons circled

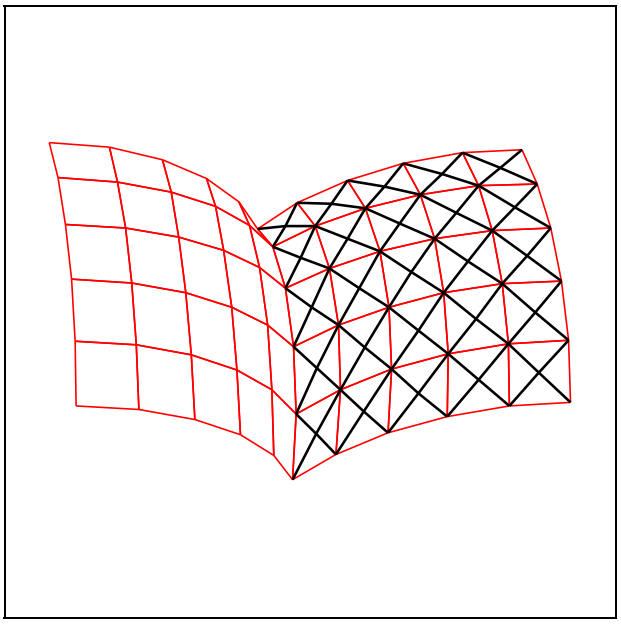


Figure 104 Selected Polygons Marked

it is difficult to determine if you have made the correct selections. One way to see if the selections are correct is to turn the polygon set into a surface. Remove all interior polygons from surfaces using the **sdint** command and draw the surface in ***Wire*** graphics mode. Alternatively, use the mouse to rotate and as you rotate, you will only see the edges of the new surface. If there are unexpected edges, then you need to modify the polygon set and try again.

After editing, you can save the active set by typing its name and hitting the ***Save*** button.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Display List Panel - Determining What Objects are Drawn

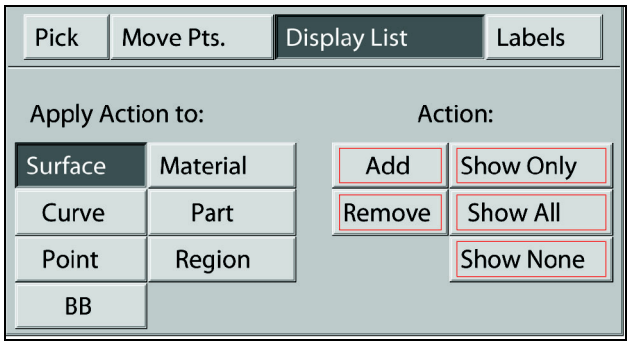


Figure 106 Display List Panel

The objects displayed in the picture are controlled by what is found in the graphical display list. This graphical display list lies within **True*Grid***®'s internal database.

For example, the ***Display List*** panel is used with the Pick panel and the mouse in the physical window to choose which surfaces, 3D curves, and block boundaries are shown in the physical window. The procedure to follow is:

Step1. Choose the type of object in the pick panel (i.e. ***Surface***, ***Curve***, (surface) ***Edge***, or ***BB***) to be selected using the mouse.

Step 2. Use the lasso (i.e. the Left Mouse Button in the physical window to form a rectangular lasso) and select the objects of the type selected.

Step 3. Choose the type of object on the left side of the ***Display List*** panel (i.e. ***Surface***, ***Curve***, or ***BB***).

Step 4. Choose the action to be taken (i.e. ***Show All***, ***Show None***, ***Show Only***, or ***Remove***).

Alternatively, a single object can be selected using labels. Steps 1. and 2. are changed above to:

Alternate Step1. Choose the type of object to be labeled in the ***Labels*** panel (i.e. ***Surface***, ***Curve***, ***Surf Edge***, or ***BB***).

Alternate Step 2. Click on the ***Label*** button in the ***Pick*** panel and select a surface in the physical window by clicking on the appropriate number in the picture.

The ***Display List*** panel can also be used with the mouse to choose which regions of the mesh are shown in both the physical and computational window. The procedure is as follows:

Step 1. Select the region or progression in either the computational or physical window. See other sections of this manual on the various methods of selecting a region or a progression.

Step 2. Select ***Region*** on the left side of the ***Display List***.

Step 3. Select the appropriate action on the right hand side of the ***Display List*** panel.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The left side of the ***Display List*** panel contains a list of all the possible objects that can be displayed. The right side contains the possible actions to be taken.

Apply Action to:

Surface	These are surfaces created using the **sd** command or imported as IGES with the **iges** or **igesfile** commands or imported as polygon surfaces using the **vpsd** command.
Curve	These are 3D curves created using the **curd** command or imported as IGES using the **iges** or **igesfile** command.
BB	Master sides to block boundaries interfaces are created using the **bb** command within a part, generated with the **mbb** command, or imported using the **getbb** command.
Part	These are parts generated using the **block**, **cylinder**, or **blude** command or imported using the **readmesh** command.

Action:

Show All	Displays all objects of the selected type (surfaces, curves, etc.) from the picture.
Show None	Removes all objects of the selected type (surfaces, curves, etc.) from the picture.
Show Only	Removes all objects of the selected type (surfaces, curves, etc.) from the picture, except for the objects that are highlighted.
Remove	Removes picked objects of the selected type (surfaces, curves, etc.) from the picture.
Add	Adds picked objects of the selected type (regions only) to the picture.

The functions available through the ***Display List*** panel are limited to objects that can be selected in the picture. The exceptions to this are the ***Show All*** function and the selection of a region or a progression using the index bars. These selection functions and more are also available through keyword commands. The keyword commands have the added function of selecting a subset of objects to be added to the picture.

Also refer to: **dsd**, **dsds**, **dasd**, **rsd**, **rsds**, **rasd** (surfaces)
dcd, **dcds**, **dacd**, **rcd**, **rcds**, **racd** (curves)
rg, **rgi**, **darg**, **arg**, **argi**, **rrg**, **rrgi**, **darged** (regions)
dm, **dms**, **dam**, **rm**, **rms** (materials)
dp, **dps**, **dap**, **rp**, **rps** (part)
dbb, dbbs, dabb, rbb, rbbs, rabb (block boundaries)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

dlv, **dlvs**, **rlv** (levels/layers)
dgrp, **dgrps**, **rgrp** (groups)

See the **DISPLAY COMMANDS** table ? for a summary of these commands.

Figure 107 was created by options ***Surface*** (***Show All***) and ***Part*** (***Show All***) and ***Wire*** from the Environment Window. **sdint off** was typed in the Text Window (also available under the ***Graphics*** menu.) Alternatively, you can type **dasd dap draw**.

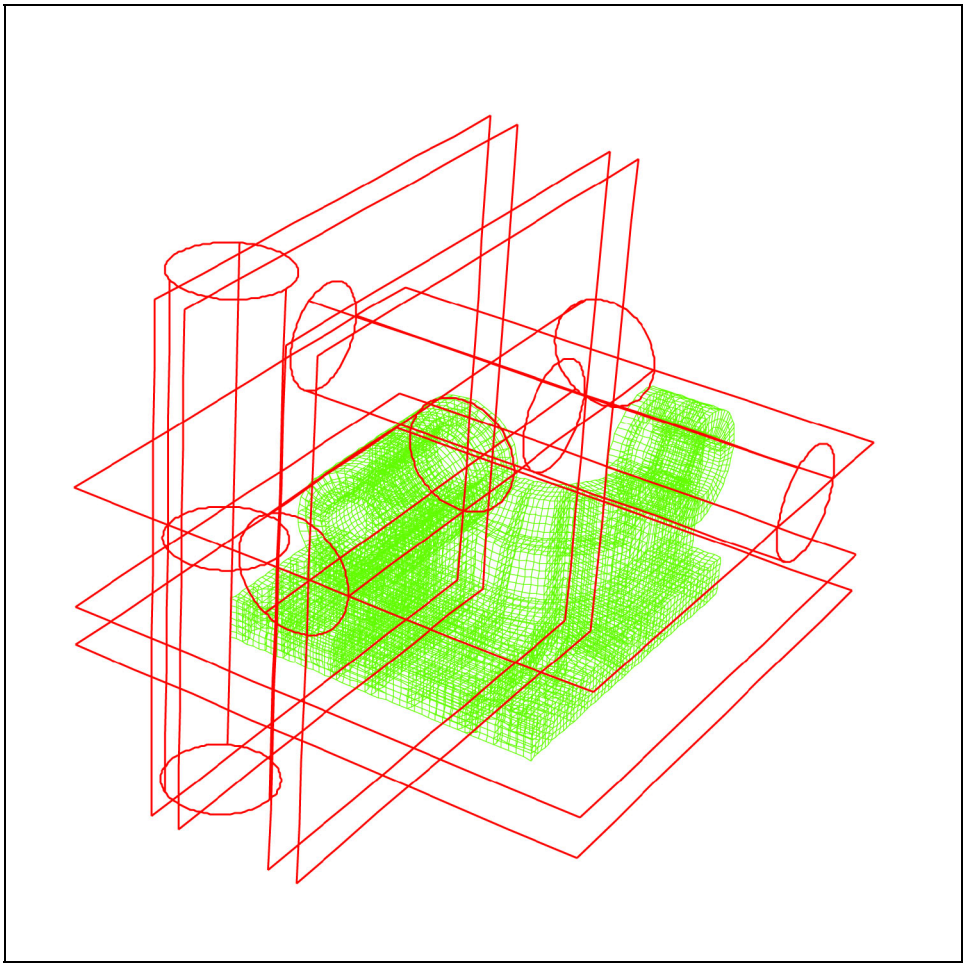


Figure 107 Surfaces and Parts

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 108 was created by options ***Surface*** (***Show All***) and ***Hide*** from the Environment Window. Alternatively, you can type **dasd disp**.

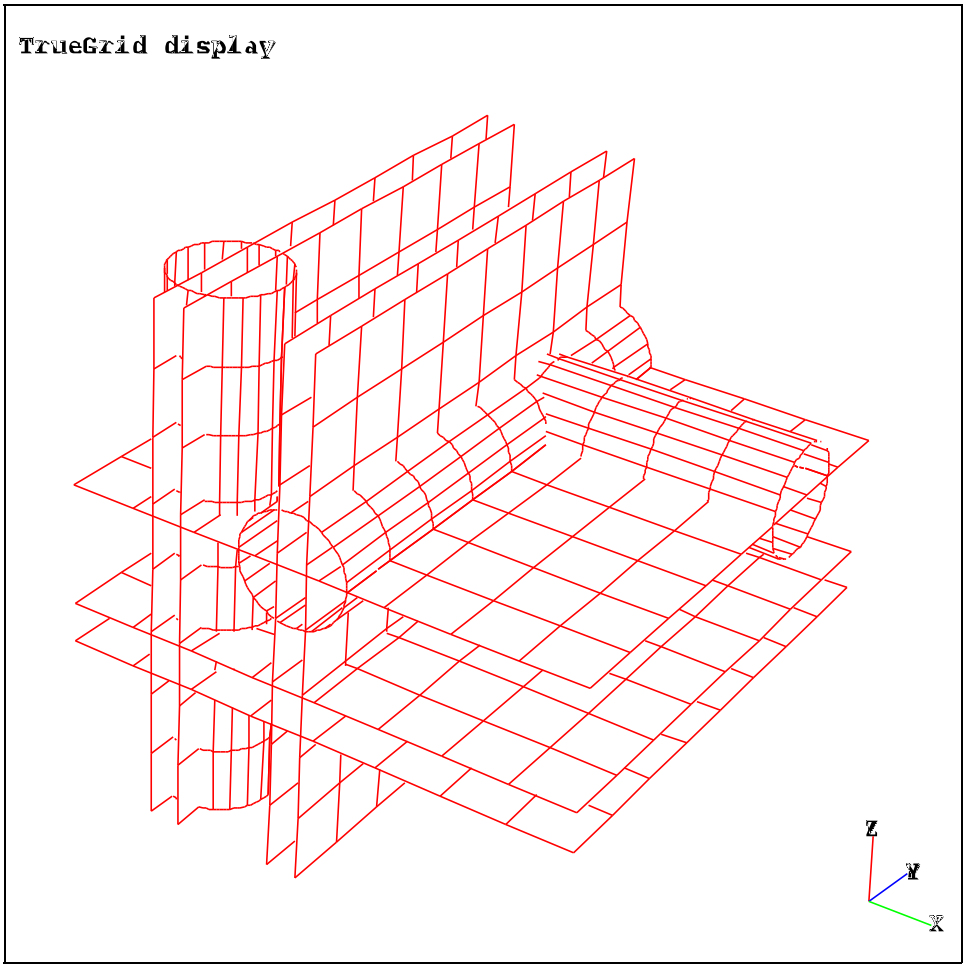


Figure 108 Surfaces in Hidden Line Picture

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 109 was created by options ***Curve*** (***Show All***) and ***Hide*** from the Environment Window. Alternatively, you can type **dacd disp**.

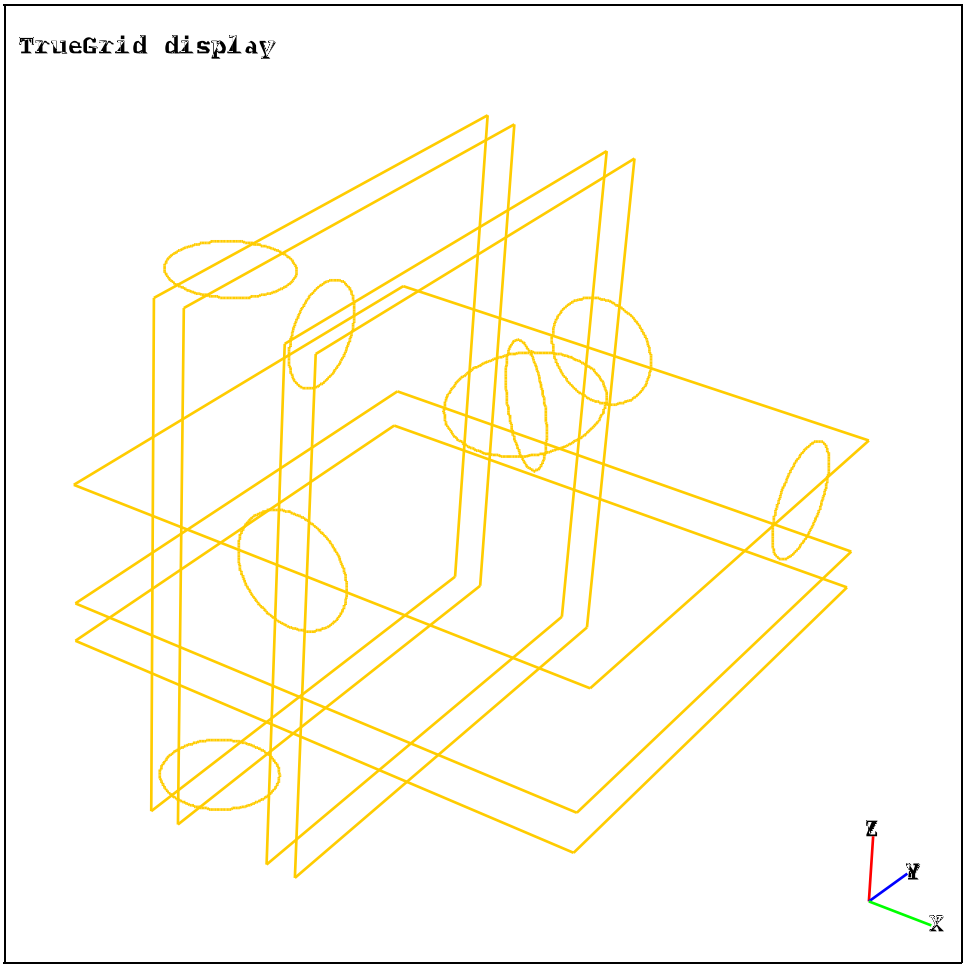


Figure 109 Curves

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Figure 110 was created by options ***Part*** (***Show All***) and ***Hide*** from the Environment Window. Alternatively, you can type **dap disp**.

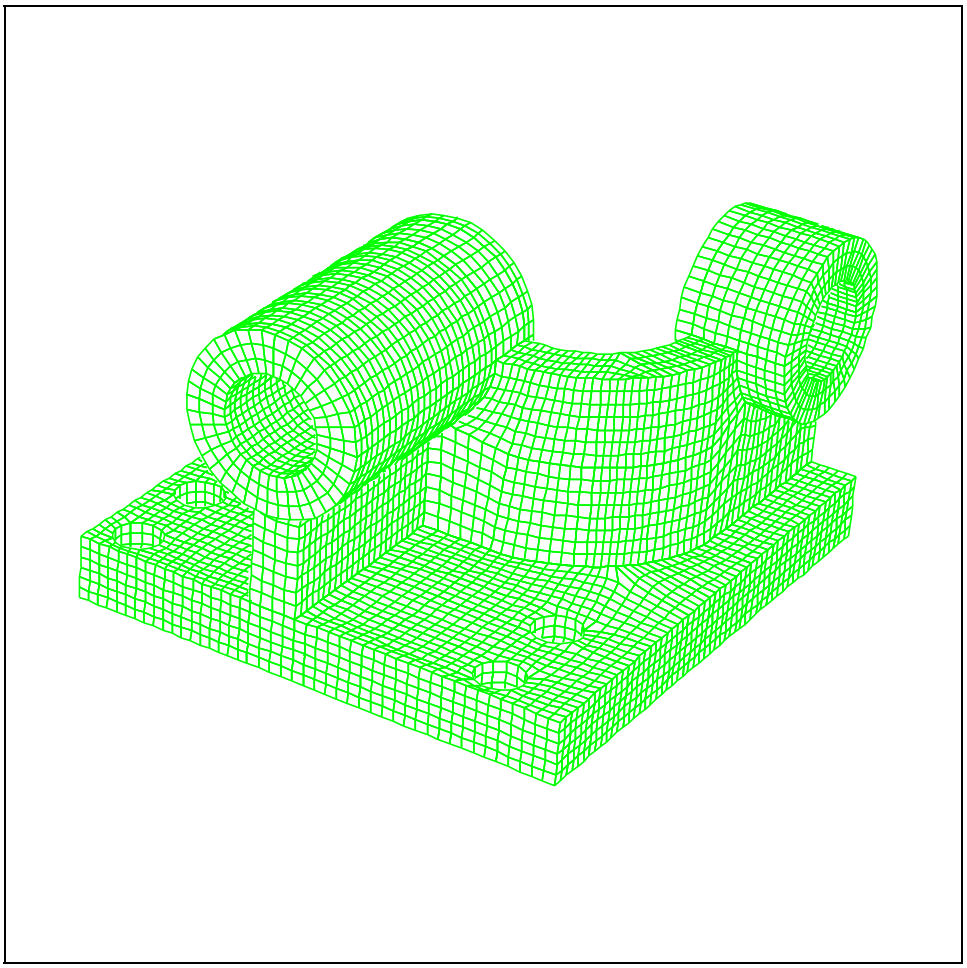


Figure 110 Mesh

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Move Pts. Panel - Interactively Moving Regions of the Mesh

The placement of portions of the mesh, controls points of 3D curves, and points on polygon surfaces is fast and intuitive using these methods. It can also be less than precise. However, the projection method usually only requires that the mesh be positioned close to its final position. The projection method makes it precise. These methods of moving the mesh can be done initially before you indicate which faces of the mesh are to be projected to which surfaces. Just as important, you can use these methods to move the mesh after you have projected the faces to surfaces. This allows you to make fine adjustments to the mesh, while it remains constrained to the surfaces of projection.

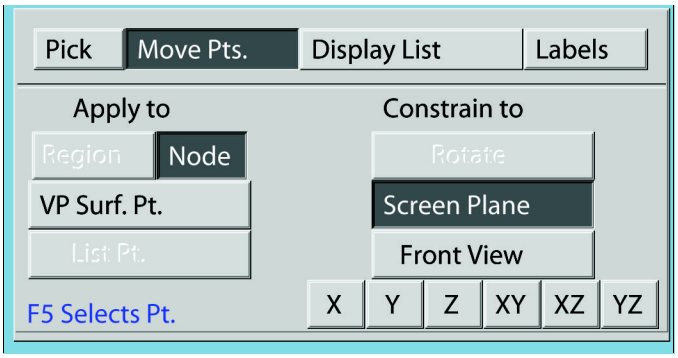


Figure 111 Move Points Panel - in Screen Plane

To move portions of the mesh, click on the ***Move Pts.*** Button in the Environment Window so that the Move Points Panel is visible. This changes the function of the left mouse. The **Apply to** list of options controls the type of object being moved. The **Constrain to** list of options controls the type of movement. This term to constrain should not be confused with the big idea of constraining the mesh to surfaces using the projection method. In the present context, **Constrain to** should be interpreted to mean that the selected object is to be allowed to move in a specific way for the present move only. Any future moves on the same object will have no lingering constraints due to this move. The default **Apply to** option in the Part Phase is a ***Region*** of the mesh. The default **Apply to** option in the Merge Phase is a single ***Node*** of the mesh.

In the part phase, any region or progression of the mesh can be repositioned with the mouse. First, select a region or progression from the computational window. If you make no selection in the computational window, then when you click the left mouse button for the click-and-drag operation, the vertex which is closest to the mouse will be selected automatically for the move.

When you select a region, the first vertex you select (with the left mouse button click or the **F5** key), the coordinates of that vertex are shown at the bottom of the Move Points Panel. In a cylindrical part, you can choose to see these coordinates in the local cylindrical or global Cartesian coordinates by clicking on the ***Global*** or ***Local*** buttons. The **F7** key will print these coordinates as shown in the Move Points Panel.

When a region or progression is selected for movement, the geometric center of mass is for a rigid body translation. A simplified outline of the region or progression and the translation vector from the old to the new center of mass is shown in white as you move the mouse. This rigid body translation requires

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

a special definition for a **cylinder** part. This rigid body translation is done in the local cylindrical coordinate system of the part, and will appear, in the Cartesian coordinate system as anything but a rigid body motion unless you are only moving the mesh in the z-direction of the local cylindrical coordinate system.

A similar feature is available in the merge phase, where only one node at a time can be moved. In this case, move the mouse close to a single node in the physical window and click the **F5** key. Moving nodes in the merge phase should be reserved for special cases because if, in the future, you make any changes to the mesh and rerun the session file, such as changing the mesh density, then the **pn** command, which is automatically generated when you move a specific node, must be scrapped and redone.

Now select the type of move operation you wish to perform (listed below) from the list of options found on the right hand side of the panel. The region, progression, or node which you have selected is moved by a click-and-drag operation with the Left Mouse Button in the Physical Window.

In the part phase, as you move the mouse in the physical window during this click-and-drag operation, you will notice that the displacement vector for the center of mass of the region, center of mass of the progression, or vertex will be displayed as scrolling coordinates at the bottom of the Move Points Panel. When you release the Left Mouse Button, the displacement vector at that point is used to modify the mesh by issuing a **pb**, **mbi**, or **tr** command containing this displacement. This command will be printed in the text window and the session file (tsave). The displacement is done in the coordinate system of the part. In the **block** part, the displacement is in Cartesian coordinates. In the **cylinder** part, the displacement is done in the selected cylindrical coordinate system (see the **cycorsy** command).

In the merge phase, as you move the mouse in the physical window during this click-and-drag operation, you will notice that the coordinates of the new nodal position will be displayed as scrolling coordinates at the bottom of the Move Points Panel. When you release the Left Mouse Button, these new coordinates will be used to reposition the selected node using the **pn** command. This command will be shown in the text window and in the session file (tsave). This type of move is always done in the global Cartesian coordinate system.

Any movement under way can be aborted by dragging the mouse out of the Physical Window and releasing the Left Mouse Button.

Apply to options list:

Region	A region or progression of the mesh can be selected to be moved. This is available only in the Part Phase.
Node	A node of the mesh can be selected to be moved using the **F5** key. This is available only in the Merge Phase.
Poly Surface	Points that form a polygon surfaces can be selected to be moved by using the **F5**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

key.

Point List Control points for various types of interactive 3D curves (such as ***LP3***, ***TWSURF***, ***SPLINE*** in the ***3D CURVE*** menu) can be selected to be moved using the **F5** key.

Constrain to options list:

Rotate Rotates the selected region as a rigid body about the line perpendicular to the screen where the mouse button was pressed in a click-and-drag motion. A wire frame outline of the region is highlighted and shown being rotated as the mouse is moved around the axis of rotation.

Screen Plane Moves the region in a plane parallel to the viewing plane. This parallel plane will pass through the selected vertex or node or, if a region or progression was selected, through the original center of mass. This option is not available for any object except a vertex while creating a **cylinder** part.

Front View This is used primarily for a single vertex in the Part Phase or a single node in the Merge Phase and when the displayed picture is in ***Hide*** or ***Fill*** graphics mode. If it is used with a region or progression, the function will be the same as in ***Screen Plane***. When a vertex or node is selected, the tip of the displacement vector will be moved along what ever is visible in the picture. When there is nothing in the picture beneath the mouse, then the point drops to an arbitrary back plane. This option is not available for any object except a vertex while creating a **cylinder** part.

X, ***Y***, ***Z*** Choosing any of these causes the region to be moved only in the **local** x, y, or z directions, respectively. In the cylinder part, ***X*** means the radial coordinate and ***Y*** means the angular coordinate.

XY, ***XZ***, ***XY*** Choosing any of these causes the region to be move in one of the **local** coordinate planes. In the cylinder part, ***X*** means the radial coordinate and ***Y*** means the angular coordinate.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Interactive Move by Rotation

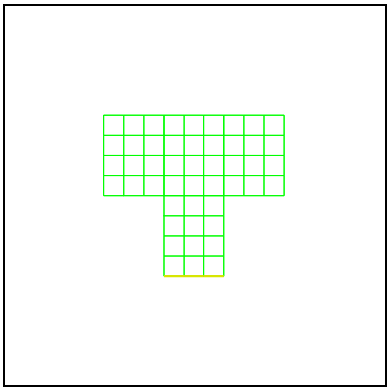


Figure 112 View before rotate

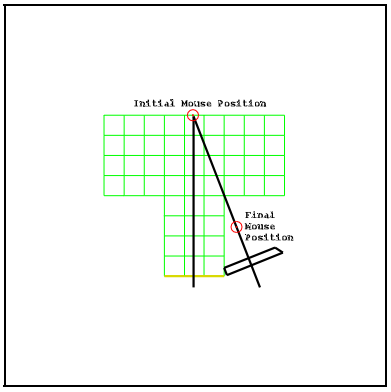


Figure 113 Click-and-drag

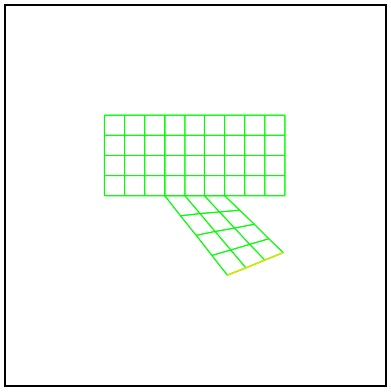


Figure 114 Final rotate

1. Select a region, progression, or node of the mesh.
2. Click on ***Rotate*** in the ***Move Pts.*** Panel
3. Rotate the picture so that the desired rotation of the selected region or progression of the mesh will be parallel to the screen. Frequently, a rotation of this type is done in one of the coordinate planes, and to do this, click on the ***rest*** button. Then type in a rotation such as **rx** 90 or **ry** 90. Setting the angle of perspective to zero (**angle** 0) may also be helpful by getting an orthogonal projection of the mesh.
4. With the left mouse button in the physical window, click and hold the left mouse button down. This establishes the center of rotation. If this is not a good choice and if you wish to try again, keep the mouse button depressed and move the mouse out of the physical window. Then let go.
5. Once you have chosen the appropriate center of rotation, move the mouse away from the center of rotation. The white skeleton of the mesh selection and the displacement vector will warp to the mouse position. The further you move the mouse from the center of rotation, the more control you will have in selecting the final rotation.
6. When the skeleton or displacement vector of the selected region, progression, or node of the mesh is in position, let go of the mouse button.

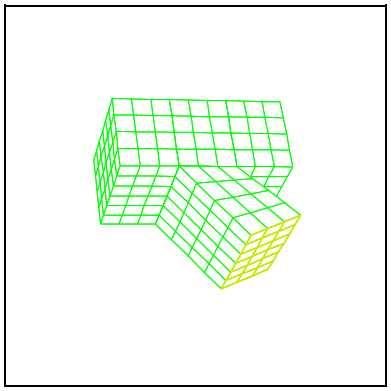


Figure 115 Rotate final view

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Interactive Move by Screen Plane

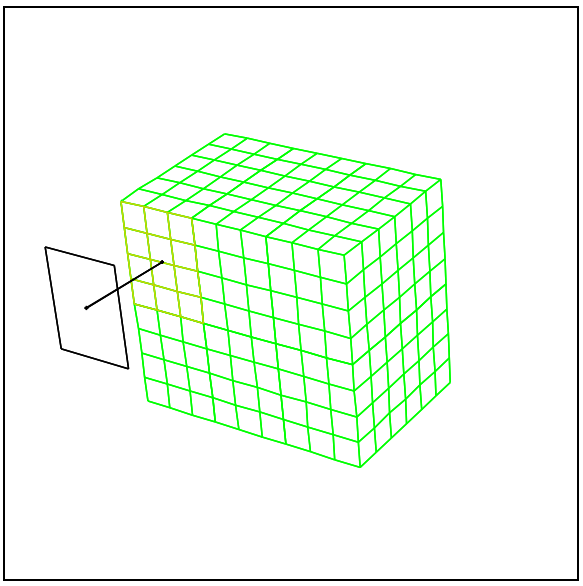


Figure 117 Screen Plane move - before

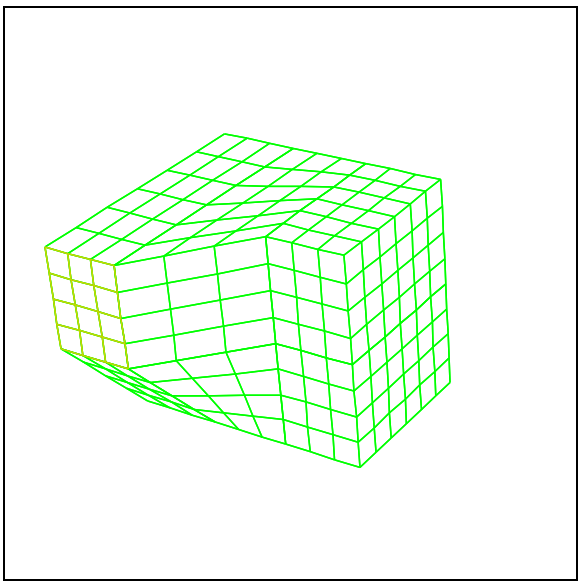


Figure 116 Screen Plane move - after

1. Select a region, progression, or node of the mesh.
2. Click on ***Screen Plane*** in the ***Move Pts.*** Panel
3. Rotate the picture so that the desired move of the selected region, progression, or node of the mesh will be parallel to the screen.
4. With the left mouse button in the physical window, click-and-drag. The white skeleton of the mesh selection and the displacement vector will warp to the mouse position.
5. While holding the mouse button down, move the mouse.
6. When the skeleton of the selected region, progression, or node of the mesh is in position, let go of the mouse button.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Interactive Move by Front View

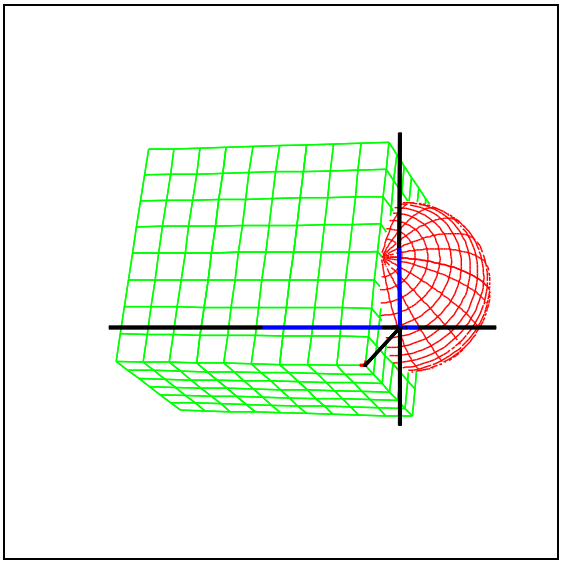


Figure 118 Front View w/ cross hairs

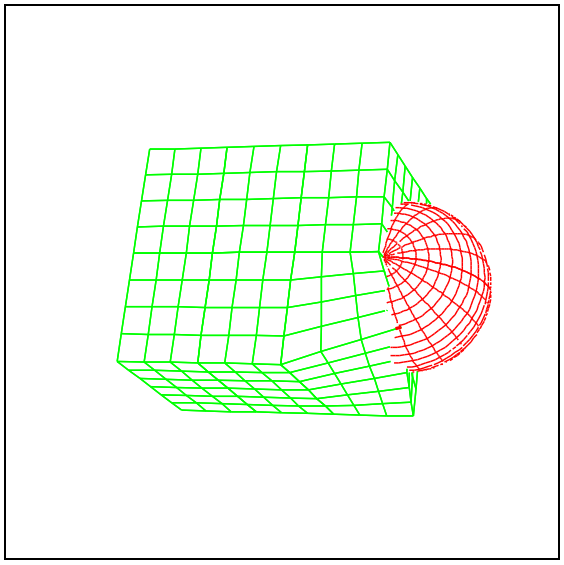


Figure 119 Front View move

1. Select a vertex (part phase) or a node (merge phase) of the mesh.
2. Click on ***Front View*** in the ***Move Pts.*** Panel
3. Draw the picture in ***Hide*** or ***Fill*** graphics.
4. With the left mouse button in the physical window, click-and-drag. The displacement vector and cross hairs will warp to the mouse position. The cross hairs are located directly on top of the object in the picture. You cannot see this because there are no direct visual clues which indicate the position perpendicular to the screen. There is an indirect clue. Notice that a portion of the cross hairs are colored blue. The blue indicates that these portions of the cross hairs are under the objects in the picture.
5. While holding the mouse button down, move the mouse.
6. When the displacement vector and cross hairs of the selected vector or node of the mesh is in position, let go of the mouse button.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Interactive Move by Constraint in One or Two Coordinates

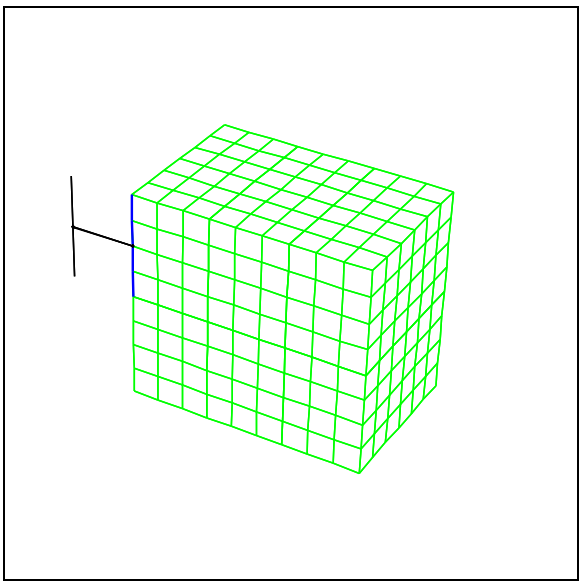


Figure 120 Move in x-direction - before

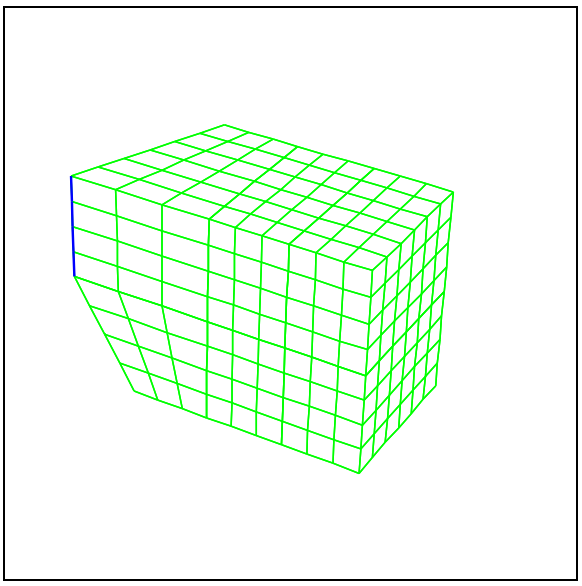


Figure 121 Move in x-direction - after

1. Select a region, progression, or node of the mesh.
2. Click on ***X***, ***Y***, ***Z XY, YZ, or XZ*** in the ***Move Pts.*** Panel
3. With the left mouse button in the physical window, click-and-drag. The white skeleton of the mesh selection and the displacement vector will warp to the mouse position.
4. While holding the mouse button down, move the mouse.

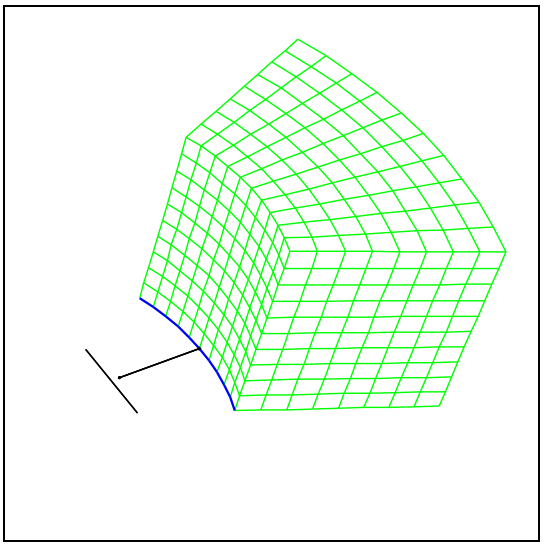


Figure 122 Cylinder part move - before

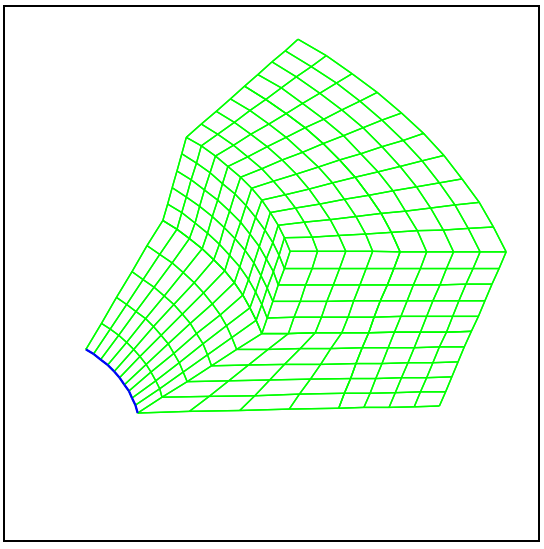


Figure 123 Cylinder part move - after

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

5. When the skeleton of the selected region, progression, or node of the mesh is in position, let go of the mouse button.

Move 3D Curve Control Points

There are three types of 3D curves that can be generated interactively by selecting points with the mouse. They are ***LP3***, ***SPLINE***, and ***TWURF***. All three use the **Point List** window to form a table of control points. To use the mouse to interactively modify the coordinates of one of these control points, first select one of the control points. This can be done in three ways.

1. click on the row corresponding to the control point to be modified
2. move the mouse close to the control point in the picture and click the **F5** key
3. use the arrow keys to scroll the focus of the curser to the desired control point

In the ***Move Pts.*** Panel, click on the ***Point List*** button under **Apply to**. This button is normally grey, indicating that it cannot be used. It turns black and white when you are using the Point List window, indicating it is an option. You can now move the selected control point with all the options under **Constrain to** as described above. Be sure to save this modified curve before you close the Point List window. This will produce a **curd** command in the session (tsave) file.

Move a Point in a Polygon Surface

Polygon surfaces are sometimes irregular, having been extracted from real objects that are not smooth or easily measured. Sometimes it is appropriate to modify such a surface by moving a node of the surface. A node in this context is not a node in the mesh, but a point that is used to form one or more polygons in a polygon surface.

To move such a node, display the surface and click on the ***Poly Surface*** button. Then move the mouse close to the node you wish to move and click on the **F5** key. This selects the node.

You are now ready to modify the coordinates of the selected node of the surface using any of the interactive moving functions described above. This action will produce a **pvpn** command in the text window and the session (tsave) file.

Note that the selection was a node in a polygon surface, not a vertex (Part Phase) or node (Merge Phase) in the mesh. The Region or Node button must be pressed to return the **F5** key function to selecting from the mesh instead of a node of a surface.

After changing a point in a polygon surface, you may wish to save that surface using the **wrsd** command. If you do and if you keep the session file to be rerun, you should modify the session file so that you are getting the new surface, not the one that requires modifications. In this case, you should also remove

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

the **pvpn** command from the session file.

Deleting a Region of the Mesh

Figure 124 Delete Button

The ***Delete*** button removes portions of the mesh.
This is one of the most important features because it is easy to define a multi-partitioned block and then whittle it down to conform to the desired geometry. The procedure is to select a region or index progress and click on the ***Delete*** button. This feature is equivalent to using the **de** or **dei** command. When you click on the ***Delete*** button, the equivalent **dei** command is printed to the text window and the session file (tsave). This action is available in the Part Phase only.

In the following figures, the mesh region was at first highlighted (cyan) in the Computational Window (**Figure 125**). The highlighted mesh region is deleted by pressing the ***Delete*** button (**Figure 126**).

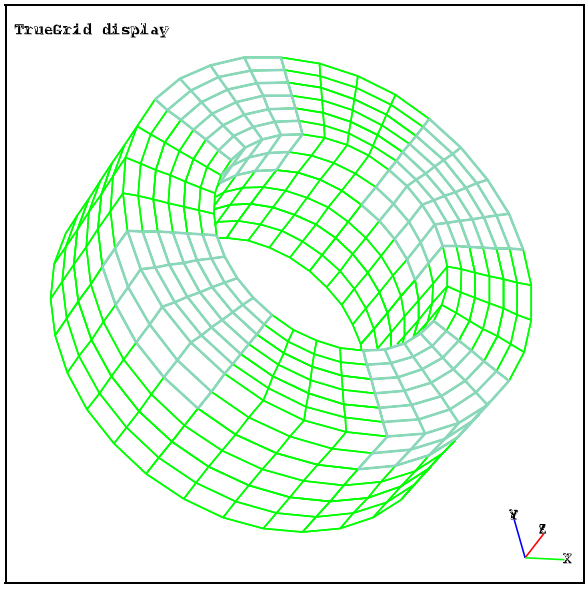


Figure 125 Before Delete

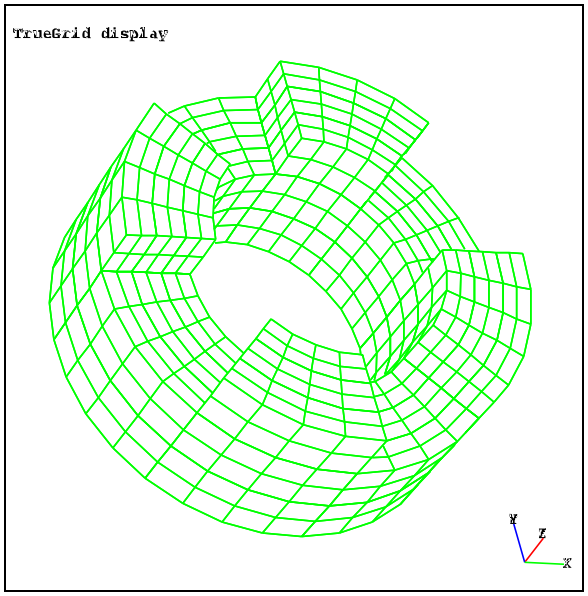


Figure 126 After Delete

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Attaching the Mesh to Objects

Figure 127 Attach Button

The ***Attach*** button is equivalent to changing the initial coordinates of a region of the mesh. These initial coordinates are used by the projection method to place the selected region of the mesh to the closest points on surfaces (portions of the mesh can be projected to surfaces using the ***Project*** button). It is necessary to have the mesh positioned close to surfaces before projection in order to get the expected results, where close means close enough that the projection algorithm converges. There is a wide variety of mesh initialization functions and the appropriate initialization function is automatically selected by the ***Attach*** button. The ***Attach*** button only functions when a region has been selected. Index progressions are not allowed with this button. The attach procedure takes three steps.

1. select the region to be attached
2. select the object to be attached to
3. click on the attach button

You may also need to make a coordinate selection in the ***Pick*** panel by activating or deactivating some of the coordinates before you click on the attach button.

You can attach a portion of the mesh to several types of geometric objects. Clicking the ***Attach*** button will print a command to the text window and the session file (tsave) which performs the appropriate function such as the **pb, pbs**, **curs**, **edge**, **patch**, **cur**, **cure**, **curf**, and **bb** commands. The command that is printed depends on the type of mesh object and the type of geometric objects. The mesh object can be a vertex, edge, face, or block (any region). In this context, the geometric object can be a point, a 3D curve, a surface edge, a surface, a node of the mesh, or a block boundary interface.

The order of attachments is important among all the attachments. For example, a vertex is attached to

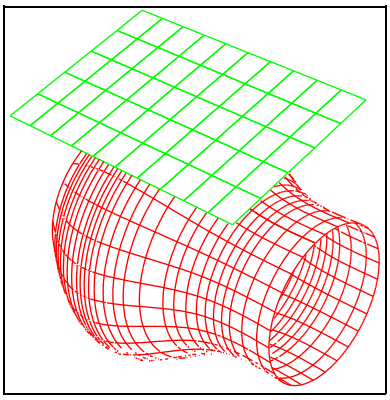


Figure 128 Before

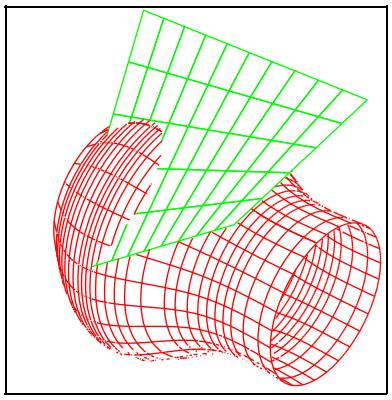


Figure 129 1st attachment

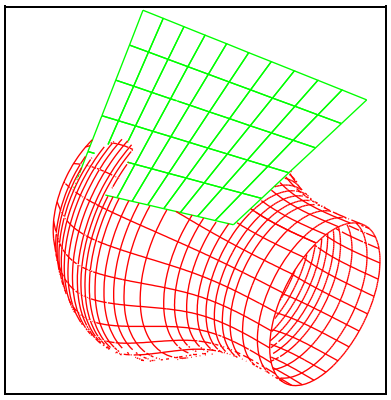


Figure 130 2nd attachment

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

a point on a surface. Then the same vertex is attached to a different point on the surface. Since attachments are not permanent (not a constraint), an object of the mesh will end up in the last place it is put. This is so intuitive that is seems not worth saying, except that it will be contrasted with the projection to surfaces. The order in which commands are executed, internal to **True*Grid*®,** is known as the command hierarchy. The rules of the command hierarchy are important in understanding projections to surfaces.

The last place a mesh object is placed becomes the starting point for the projection to a surface. Attachments can be made before or after a projection to a surface. In this example, the mesh shown above is projected to the surface. Then the vertex in the lower right corner is attached to a different point on the surface.

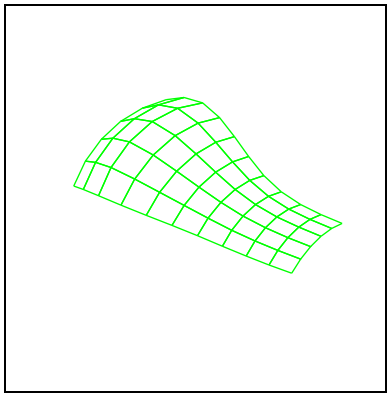


Figure 131 After projection

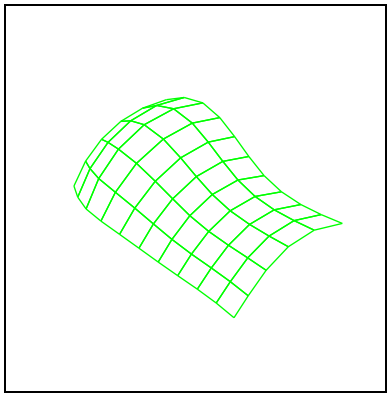


Figure 132 3rd attachment

These attachments create the **pb** command in the text window and the session file (tsave).

If the result of an attachment is not satisfactory, use the ***Undo*** button and try another object for attachment.

See also : **pb, pbs**, **curs**, **edge, patch, cur, cure, curf, bb**.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Attaching an Edge of the Mesh to a Curve

You can shape any edge of the mesh by attaching it to a 3D curve. The vertices of the selected edge are placed onto the closest points on the 3D curve. Then the interior nodes of the edge are distributed along the 3D curve.

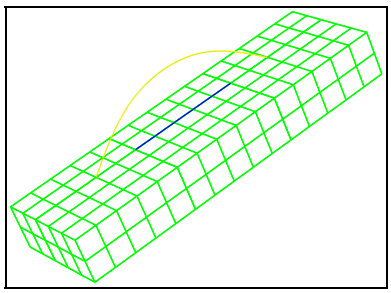


Figure 133 Before attachment

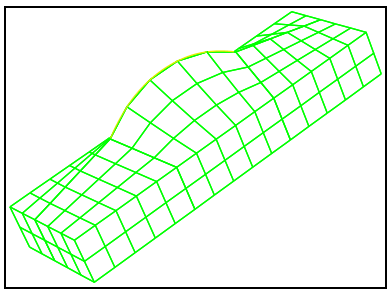


Figure 134 After attachment

The command generated by this action will be printed to the text window and to the session file (tsave). The **curtyp** command controls which type of the curve attachment is used when the attach button is depressed after a 3D curve has been selected. The default is **curs**. The curs command has the feature that if you select a multiple edge of the mesh, each simple component edge will be placed onto the 3D curve independent of the others.

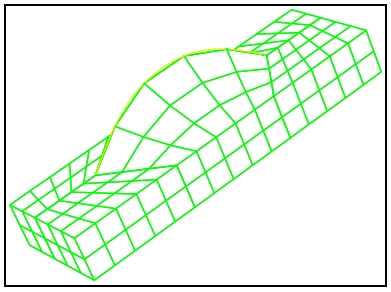


Figure 135 Cure attachment

In contrast, if the **curtyp** is set to **cure**, the resulting attachment will place the end vertices of the edge of the mesh to the end points of the 3D curve (instead of the closest point on the 3D curve).

Vertices are attached to points (see the other forms of this attach function) before edges are attached to 3D curves, regardless the order in which these commands are generated. This gives you the option to move the vertices on the edge into a better position after you have attached the edge to the 3D curve.

Also see the commands **cur**, **curs**, **cure**, and **curf** for a complete discussion on attaching an edge to a 3D curve.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Attaching an Edge of the Mesh to an Edge of a Surface

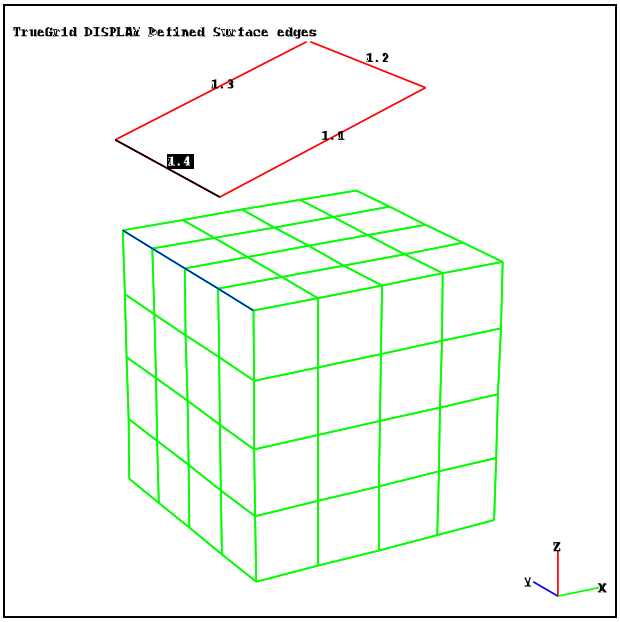


Figure 136 Before Attach

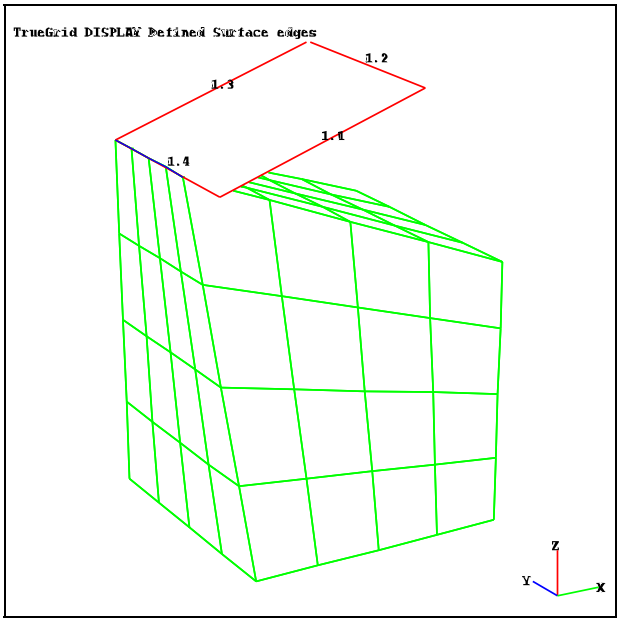


Figure 137 After Attach

Figure 136 and **Figure 137** show an attachment of an edge of the mesh (blue) to edge 1.4 (grey) of surface 1. The mesh edge was previously selected in the Computational Window (see pg.111) and the surface edge was picked by ***Label*** in the Physical Window.

This type of attachment produces the **edge** command in the text window and the session file (tsave). This command treats all interior vertices of a multiple edge of the mesh as interior points, making this option less flexible. You may be tempted to use this command in the early stages of creating a mesh. However, if you should need to insert a partition (**insprt** command) at a later time, the resulting new vertex will have no freedom to be moved along this edge. If you think that you might insert a partition at a later time, it is best to form a 3D curve from this edge using the **sdedge** option of the **curd** command and attach to the 3D curve.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Attaching a Mesh Edge to a Lassoed Block Boundary

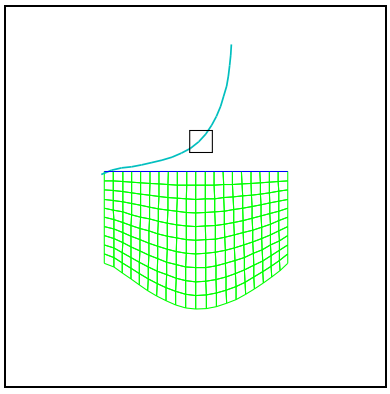


Figure 138 Lasso a BB

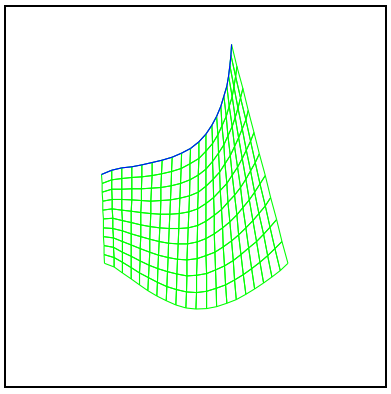


Figure 139 Attach mesh to BB

In this example, an intra-part master block boundary interface is selected with a lasso. This form of attachment prints a **bb** command to the text window and the session file (tsave). There are many options to the **bb**, and the related **trbb**, command. A block boundary interface can be formed from a vertex, edge, or face of the mesh. This is a way to glue two parts together or form periodic boundaries of the mesh.

```
block 1 11 21;1 11;-1;1 2 3 0 1 0
pb 2 1 1 2 1 1 y -.5
splint 1 1 1 3 1 1 i 11 2 0 0 1 1 0
bb 1 1 1 3 1 1 1 mx .375 rz 45;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Attaching a Mesh Edge to a Point Picked by Z-Buffer

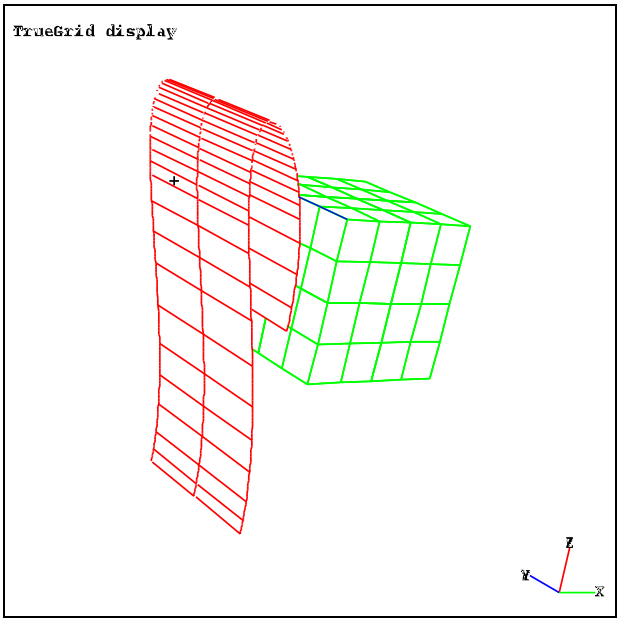


Figure 140 Before Attach

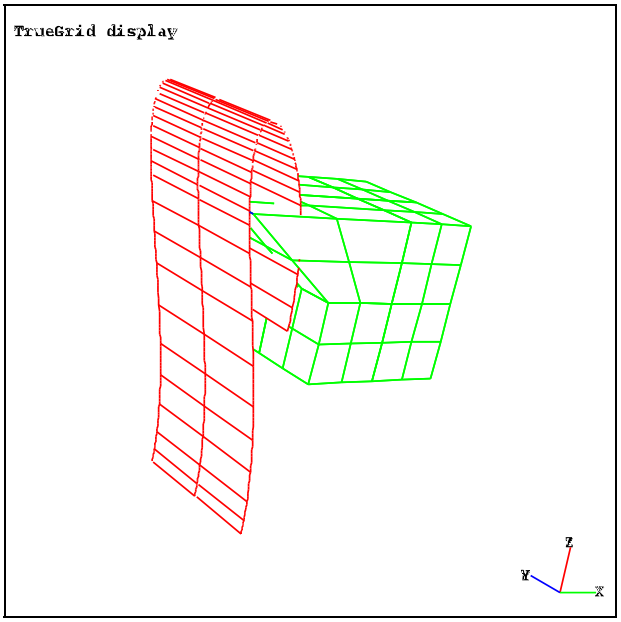


Figure 141 After Attach

Figure 140 and **Figure 141** show an attachment of an edge of the mesh (blue) to the visible point (+) on the surface. The mesh edge was previously selected in the Computational Window and the surface point was picked by ***Z-buffer*** in the Physical Window. Only the x- coordinate was checked in the ***Pick*** panel, so only the x-coordinates of the edge were re-assigned.

This attach produces a **pb** command in the text window and the session file (tsave).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Attaching a Vertex to a Point Picked by Projection

While in the ***Pick*** panel, select a single surface or a single curve. While this single surface or single curve is highlighted, click on the ***Projection*** button (not the ***Project*** button). Now move the mouse into the Physical Window and click with the Left Mouse Button. The point on the selected surface or curve which is closest to the mouse is marked with the "+". The ***Attach*** button can be used to assign coordinates of the point to a region of the mesh.

This action produces a **pb** command in the text window and the session file (tsave).

Figure 142 and **Figure 143** show an attachment of a mesh vertex (red) to the point (+) on curve 1. This is done in the Part Phase.

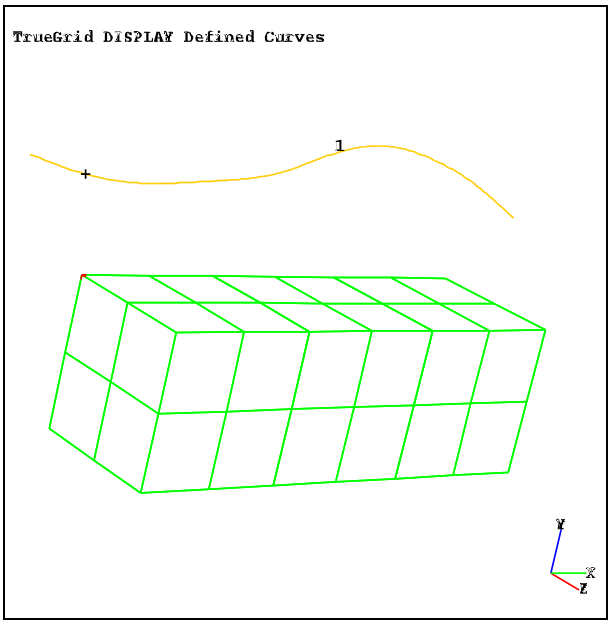


Figure 142 Before Attach

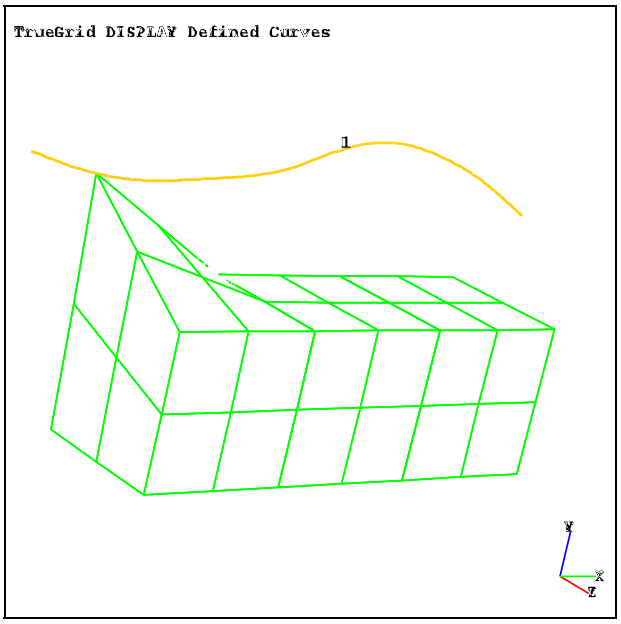


Figure 143 After Attach

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Attaching a Node to a Node

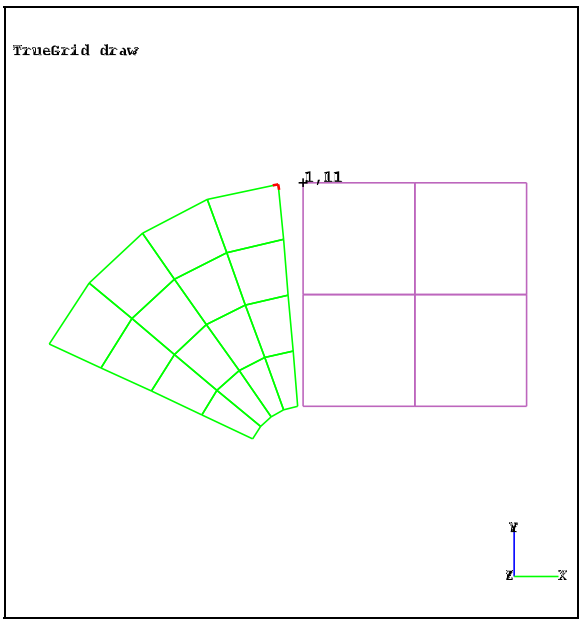


Figure 144 Before Attach

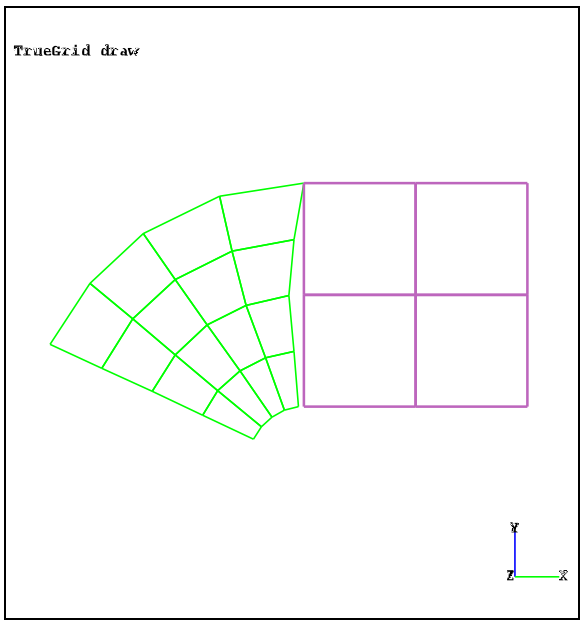


Figure 145 After Attach

Figure 144 and **Figure 145** show an attachment of a node (red) of Part 2 (green) to node (1,11) of Part 1 (purple). Where the notation (1,11) means Part 1 and the global node number 11. This is done in the Part Phase. Both parts are displayed by the **dap** command.

You can also attach a region of the mesh to a node (usually a vertex) in the same part. This is useful when creating triangular shells, or wedges and tetrahedron brick elements. When you attach a vertex to a neighboring vertex in the part, all of the nodes between the two vertices are assigned the same coordinates. At this stage, the elements look like triangles, wedges, or tetrahedrons, but they still have a full set of nodes (4 in the case of shells, 8 in the case of bricks), some of which are coincident. Only after entering the merge phase and issuing a merge command, like the **stp** command, do the coincident nodes become one node.

This attach function produces a **pb** command in the text window and the session file (tsave).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Projecting a Mesh Region to a Surface

Figure 146 Project Button

To project a region or index progression of the mesh onto a surface, select a single or composite surface and click on the ***Project*** button.

Projection imposes constraints. The mesh region or index progression can still be moved but only along the surface of projection. In other words, once a section of the mesh has been projected onto a surface, it will stay on that surface. If you are not satisfied with the results of the projection, either move the mesh region along the surface or click on the ***Undo*** button.

In the case that two different faces of the mesh are projected to two different surfaces and the two faces share an edge, that common edge will be placed onto the 3D curve forming the intersection of the two surfaces. In the case that three different faces of the mesh are projected to three different surfaces and the three faces share a vertex, then the common vertex will be placed at the closest point of intersection of the three surfaces. It is up to you to make sure that when one of these steps are taken, that the surfaces involved actually intersect. Otherwise, the calculations to build the mesh will take longer, you will receive warnings, and you will probably not like the resulting mesh. Intersecting tangent surfaces can also cause delays in the calculation. There are more advanced methods to handle tangent surfaces. It is not recommend that you project a face of the mesh onto more than one surface. You cannot project a solid region to a surface.

Clicking on the Project button produces a **sfi** command in the text window and the session file (tsave).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Projecting Mesh Faces onto a Single Surface

Figure 147 and **Figure 148** show projection of 4 face regions (yellow) onto a cylindrical surface (red). The mesh faces are first selected in the Computational Window. Then the surface is picked by label (black) and the ***Project*** button is pressed.

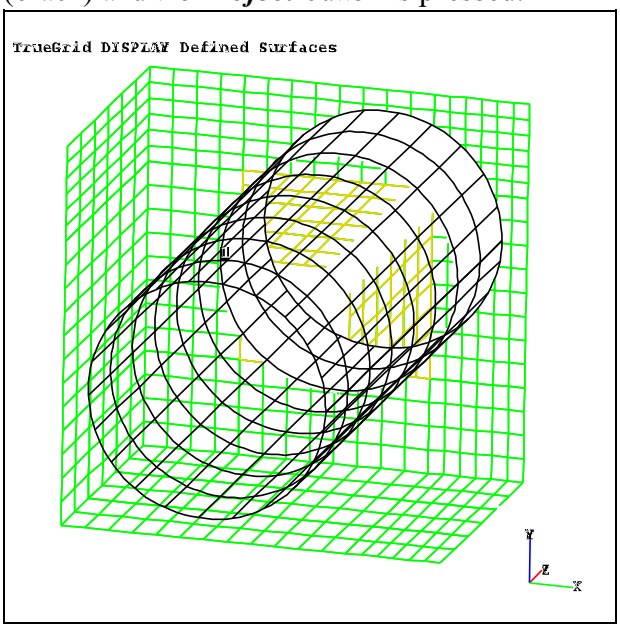


Figure 147 Before Project

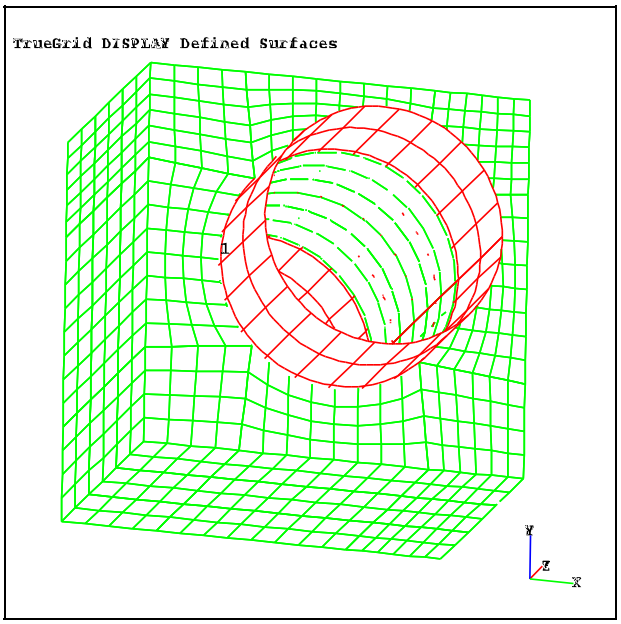


Figure 148 After Project

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Projecting Two Faces onto Two Surface

This example shows consecutive steps in projecting faces of the mesh onto 2 surfaces.

As you can see from the pictures, the two surfaces do not have a common boundary. In some areas, the surfaces do not meet, and in other areas the surfaces pass through each other. The surfaces imported from an IGES file are frequently ill defined in this way, although this example is an exaggeration of what you might typically find in a model from a CAD system. The projection method handles these inaccuracies in the geometry in the best possible way. In this example, the common edge of both projected faces forms the intersection between the pair of ill defined surfaces.

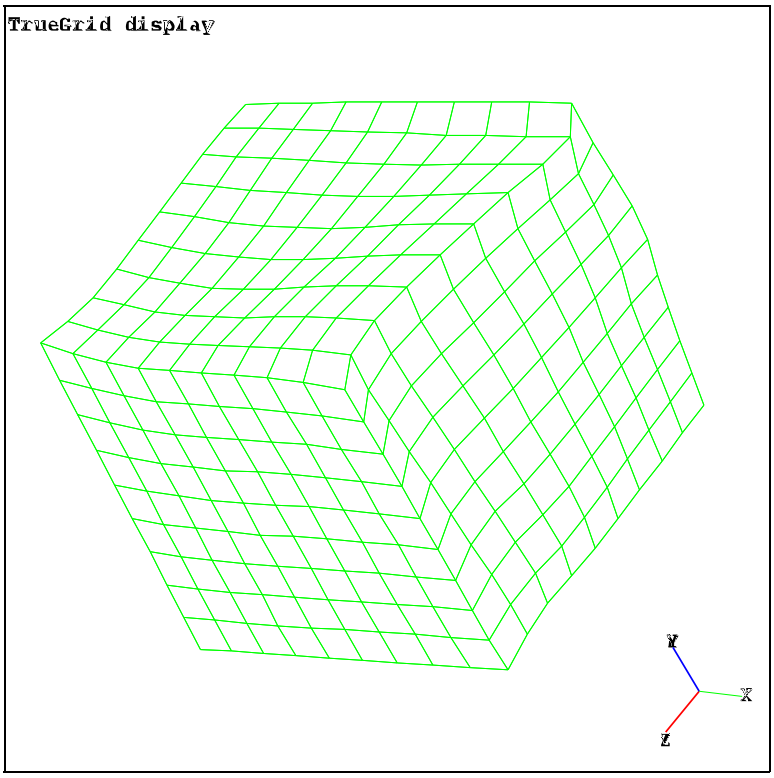


Figure 149 Projected Mesh

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

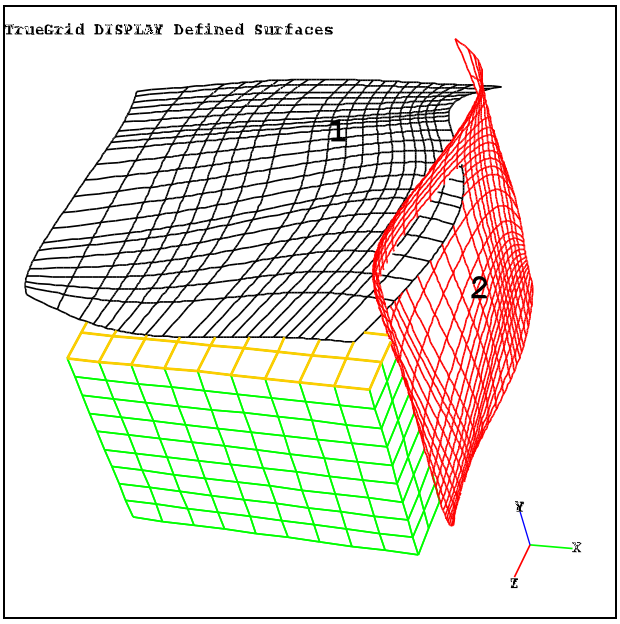


Figure 150 Step 1

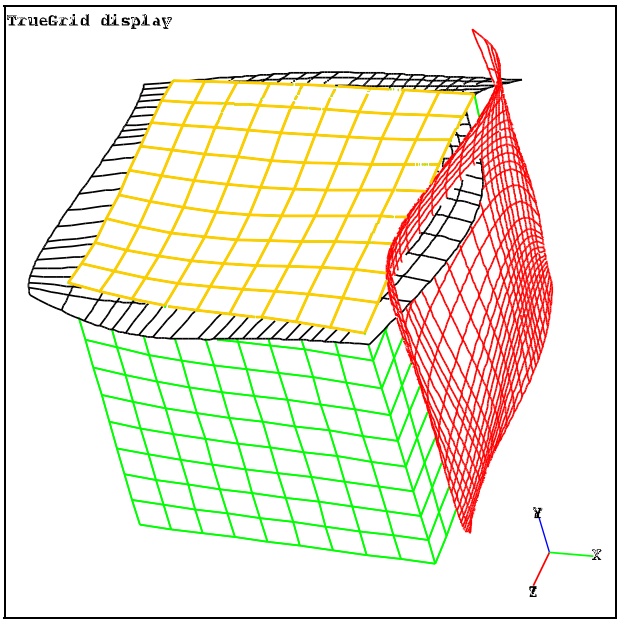


Figure 151 Step 2

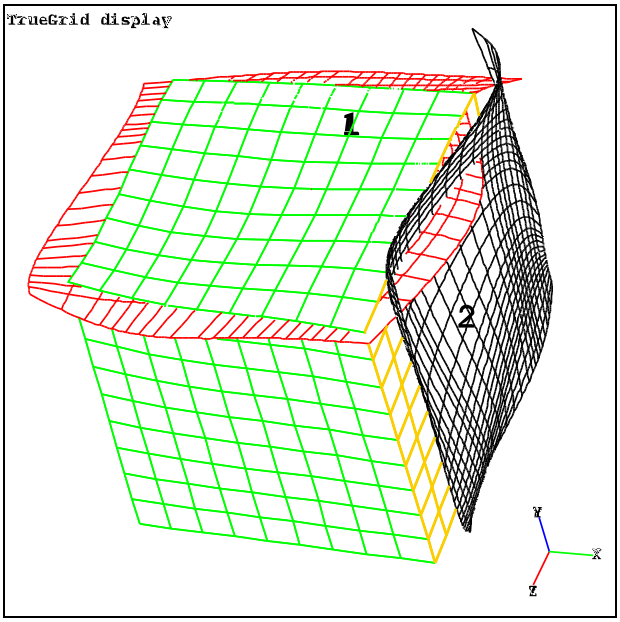


Figure 152 Step 3

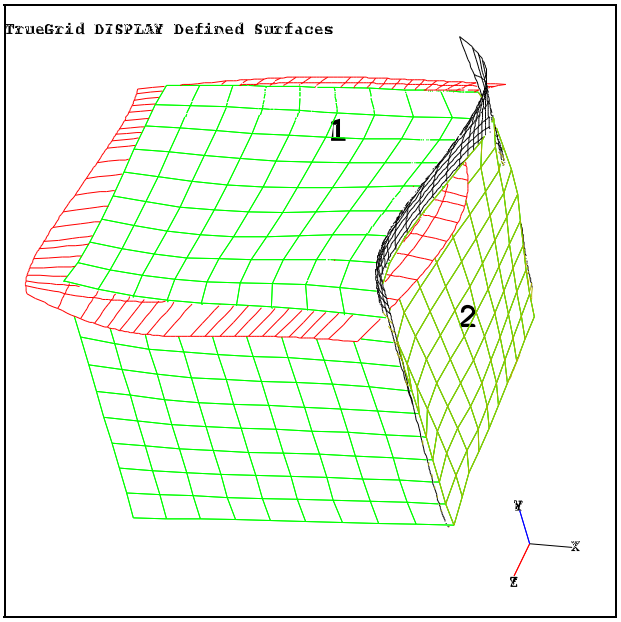


Figure 153 Step 4

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Projecting Mesh Faces onto a Single Surface and Subsequent Movement of the Mesh

The mesh face (yellow) is selected in the Computational Window and surface 2 (black) is picked by label, shown in **Figure 154**. The mesh face is projected onto surface 2 by pressing the ***Project*** button (**Figure 155**). The edge of the mesh is selected (blue) and curve 1 is picked by label (black). The edge is attached to the curve by pressing the ***Attach*** button (**Figure 121**). The vertex of the mesh (red) is selected. The vertex is moved along the surface 2 (**Figure 123**) using the ***Front View*** option of the ***Move Pts.*** panel.

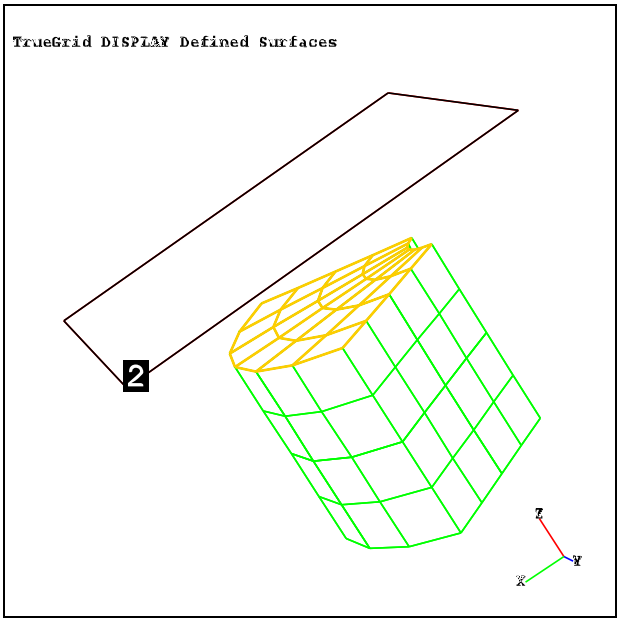


Figure 154 Step 1 : Pick face & surface

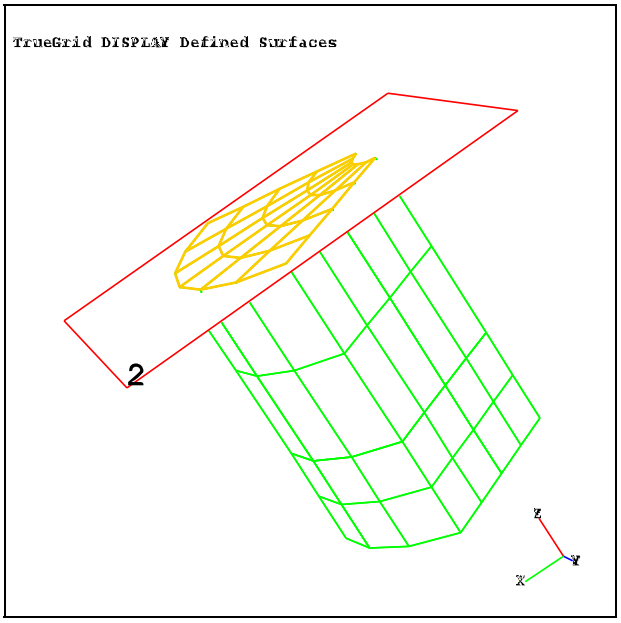
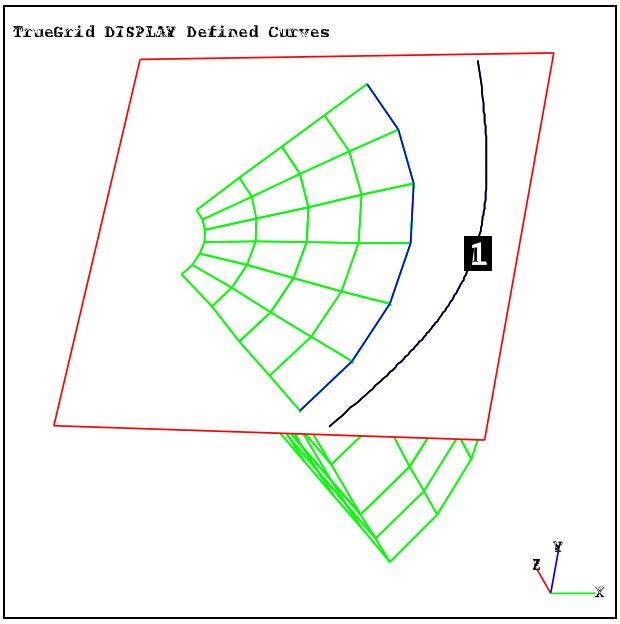


Figure 155 Step 2 : Click ***Project***

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved



150**Figure 156** Step 3 : Pick edge and curve

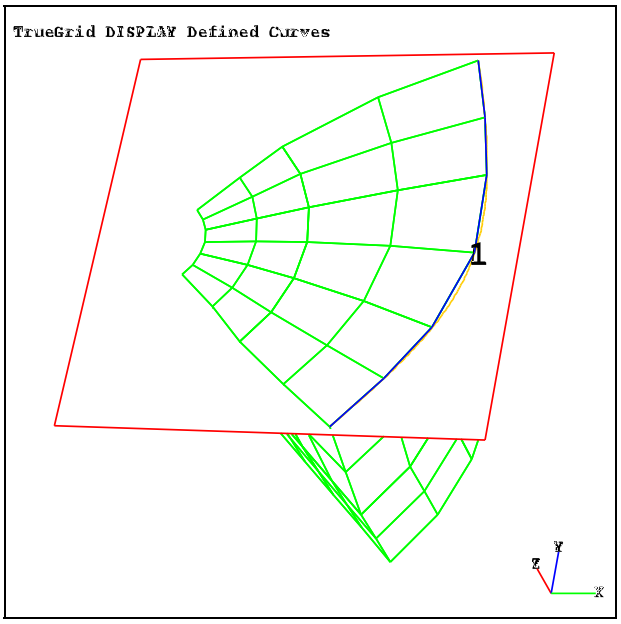


Figure 157 Step 4 : Click ***Attach***

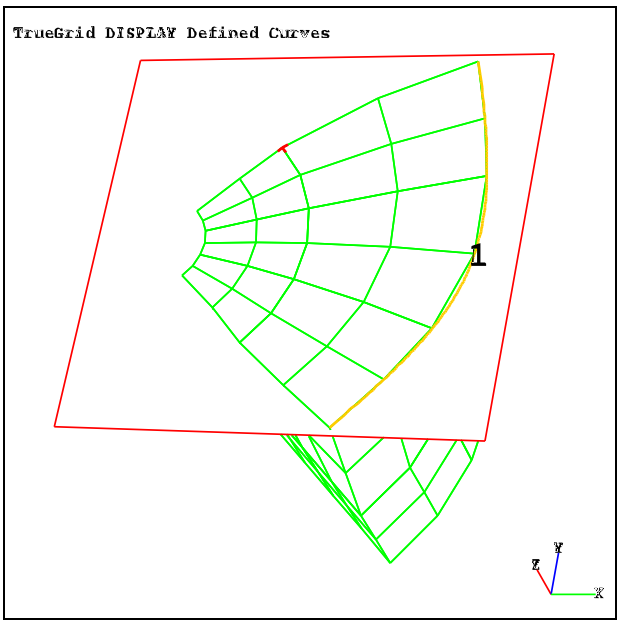


Figure 158 Step 5 : Pick vertex

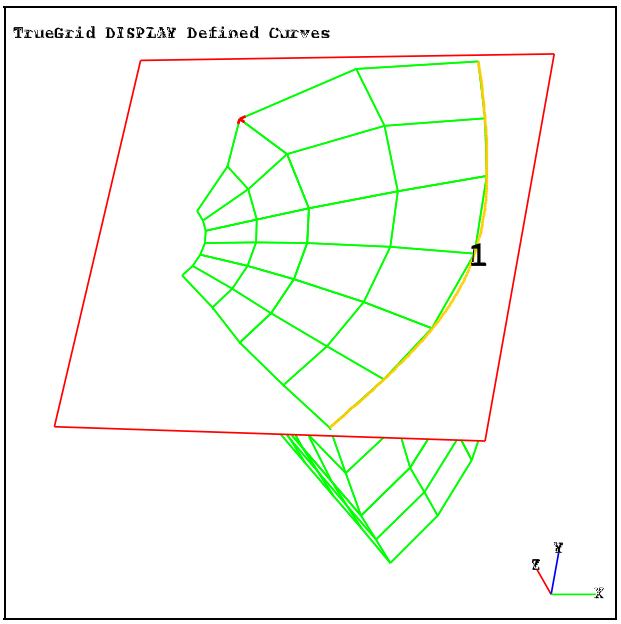


Figure 159 Step 6 : Move vertex on surface

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The Undo Feature

Figure 160 Undo Button

Press the ***Undo*** button in the Environment Window to deactivate the most recent active mesh command. This is a function only found in the part phase and does not undo all commands. For example, no database commands such as surface, 3D curve, material, or sliding interface definitions are undone. Also, no graphics commands can be undone with this function. The **insprt** and the **mseq** mesh commands cannot be undone with this function. Each time you click on the ***Undo*** button, another mesh command is undone until all the active commands for the present part are deactivated. You cannot undo the command (**block**, **cylinder**, **blude**) that started the part. If you wish to undo the entire part, type the **abort** command. These function prints an **undo** command into the session file (tsave).

The History Button

Figure 161 History Button

Press the ***History*** button to view a table of active, inactive, and deactivated mesh commands of the present part. This command is only available in the part phase. You can use this to undo an undo by reactivating a deactivated command. This can also be used to deactivate a command other than the most recent active mesh command. The most important use of ***History*** is in debugging a part. The ***History*** button does not produce a command in the text window or the session file (tsave). However, functions within the History Window may produce the **decmd** and **actcmd** commands in the session file (tsave). See the section on the History Window for more information.

The Resume Command

Figure 162 Resume Button

When an **interrupt** is encountered in a batch file that **True*Grid*®** is processing, this button will become active. Otherwise, it will be inactive and grayed out. This is designed to let you add commands interactively before resuming the execution of commands in the batch command file. Pressing the ***Resume*** button causes **True*Grid*®** to execute all commands between the current **interrupt** command in the batch file and the next **interrupt** command in the batch file (or the end of the input file). If you are having a problem with the mesh, you can **interrupt** at different stages to test the mesh. If you have an old batch file that you do not understand, placing **interrupt**s in the file will help you understand how the mesh is being constructed. You can also use this feature to modify an existing mesh. You can also use the mechanism to build demonstration models.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

7. Dialogue Boxes

When you click on a command with the left mouse button in the menus below the text window, a dialogue bow or window will appear. This window contains the options and prompts for arguments for the selected command. After you select options and fill in the necessary arguments, click on the ***EXEC/QUIT*** button to issue the command. You can also set up a command, issue it without quitting the dialogue box, edit a few command arguments, and then reissue the command.

There are four ways to create a dialogue box:

1. Select a command by left-clicking your mouse in a submenu.
2. On the command line of the text/menu window, enter "**dial** *command*". The word **dial** must appear immediately after the prompt.
3. Select a command from the history window. All options will be filled in according to the parameters in the selected command.
4. Highlight a command and all of its arguments from the text window or from any other window containing text and type Control-Z. All options will be filled in according to the parameters in the highlighted command.

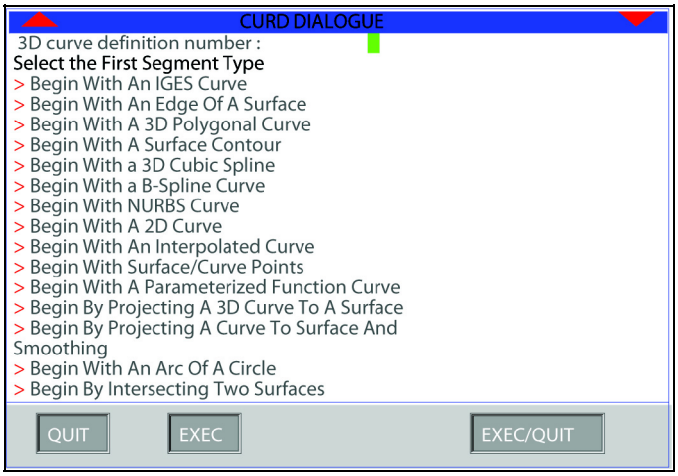


Figure 163 Dialogue Box

You can use only one dialogue box at a time. If you have a dialogue box open, you cannot create another one. If there is a dialogue box open, and you type "**dial** *command*" on the command line, the old dialogue box will be destroyed.

If not everything fits in the dialogue box, you can scroll through it or maximize the window by clicking

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

on the max/min button in the upper right corner. If you choose to maximize the dialogue box, be sure to return it to its reduced size before quitting the window. Otherwise, the next dialogue box will appear, by default, to be maximized. The red arrows in the window, the arrow keys, and the page up/down keys work as described on page 73. Dialogue boxes also offer continuous scrolling: press and hold down the Middle Mouse Button, and move it up or down. Your right mouse button will drag the contents of the dialogue box. Release the mouse button when satisfied. Another way to scroll through the dialogue box is to press Control-B for backwards or Control-F for forwards.

When your mouse is not in the text window, your keystrokes will be entered into the dialogue. You enter data into a dialogue box by using both the mouse and the keyboard. With the mouse, you may select one or more items from an option list, which is a kind of menu. With the keyboard, you type one or more numbers, or sometimes arbitrary text strings.

Option Lists

An option list is a part of a dialogue box that lets you choose items from a fixed list of alter-natives. The context determines what the options are and how many you may choose. You choose an option by left-clicking the mouse on it. You can deselect by clicking on the item again.

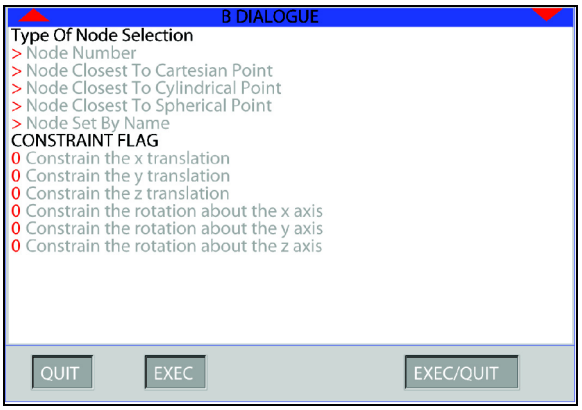


Figure 164 Exclusive and non-exclusive

There is a special case with a dialogue box that list options for different output options. In particular, the **sid**, **spd**, **bsd**, and **offset** commands. If the output option has been selected prior to using one of these dialogue boxes to make a selection, only the options available to that output option will be displayed in the dialogue box.

Appearance

Each line of the option list begins with the **red** marker ">", for exclusive, when you can choose only one item, or "0" when you can choose any number of items.

The name of the option can be displayed by typing Control-V in the dialogue window. Typing Control-V a second time hides this list.

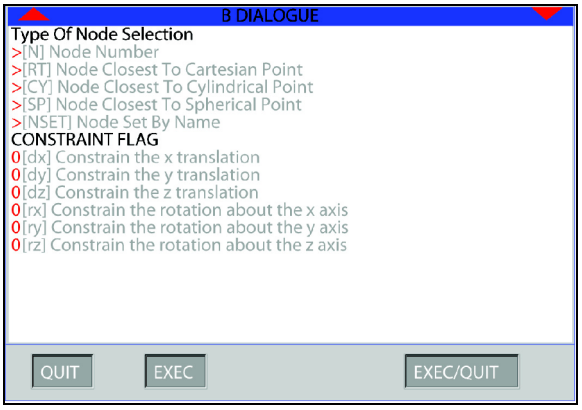


Figure 165 command names shown

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Usage

To choose an option from an options list, click the Left Mouse Button anywhere on the string following that option's red marker. You will see that option's description turn from grey to yellow. If you are only permitted to make one choice from an exclusive list, then upon choosing an option, all other options disappear from sight. If you are permitted to make more than one list choice, the remaining options will remain visible. To deselect an option, click the Left Mouse Button again on the yellow text description of that option. This action will turn the string from yellow back to grey.

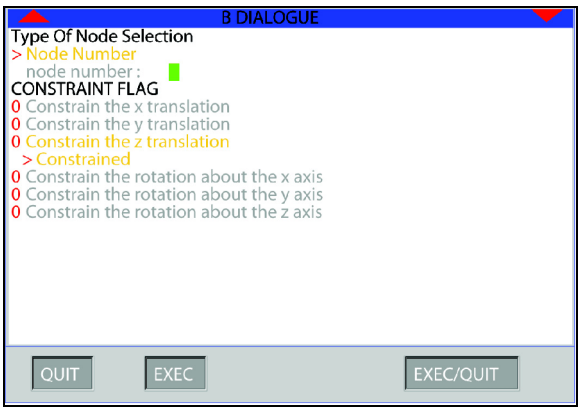


Figure 166 Selections in yellow

Sometimes the type or quantity of data a command needs depends on the options you have chosen. In these cases, the dialogue box changes as you choose options. You may have to enter numbers or choose options in places that did not exist when you first opened the dialogue box. Experienced users generally find it easiest to make all their dialogue box mouse selections first, and then they go back and enter the numerical and/or character string data.

Numbers, Lists of Numbers, and Text Strings

Dialogue boxes may also have a place for you to provide an *input string*, such as a number, a list of numbers, or a file name. These strings are to be entered from the keyboard.

Appearance

Each line where you provide an input string begins with a greyish-colored prompt, often in the form "stuff is needed here :". Sometimes a detailed description of the input requirements appears in white text above this line. Each input string is also marked by a hollow or solid green rectangle. A hollow green rectangle represents a place where a cursor could be, and the solid rectangle indicates the current position of the cursor.

Usage

The solid green cursor indicates the position where keyboard data will be entered. You can make any line's hollow green rectangle turn to a solid rectangle by clicking anywhere on that line. The “Enter” key must be used to complete the data for the a line and to advance to the next line. When you have completed a line with the keyboard “Enter” key, the green rectangle will turn red. You will not be

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

allowed to ***EXEC*** or ***EXEC/QUIT*** if there is a green rectangle at the end of a line.

Usually the context will make it clear what kind of data is needed. When in doubt, look up the relevant command use the ***HELP*** button in the menus, the **help** command, or this manual. In all cases, where a number is required, an equivalent Fortran like expression will do just as well. For example, you can type "[3/5]" rather than "0.6". (Note the required use of the square brackets encasing the expression.)

Parser and Fortran Interpreter

There are several ways to enter a number:

```
3.43e9    3.43e-09  34
```

Whenever a number is required, you may use an equivalent Fortran-like expression. This feature is key to parameterizing the geometry and topology. The expression must be enclosed in square brackets. The syntax is the same as in the Fortran (and other) programming language. An expression can contain numbers, parameters (starting with a "%"), intrinsic functions, operations such as *,+,-,**,/, and parenthesis. For example, all of the following will yield the same result:

```
[0.5]     [1/2]     [1/2.0]   [1.0/2.0] [asin(30)]
[asin(30.0)]   [1/sqrt(2)*(sqrt(2))]    [(1/sqrt(2))**2]
5.0e-1         5e-1
```

All evaluations are done as floating point and are truncated to integers were it is required.

The **para** command defines parameters which you can use in any Fortran expression. For example,

```
para  cd 0.05;
```

defines a parameter "cd" whose value is to be 0.05. The parameter "cd" can subsequently appear in any Fortran like expression but must be preceded by a "%". For example, [20*%cd] will have the value 1.0.

As soon as you define a parameter, you can use it. The following expression defines four parameters:

```
para  cd 0.05
      te [%cd*2.14159/180.0*0.05]
      ra 5.0
      rad [(%ra+1.0)*3.14159*7/54.0];
```

Note that a semicolon must end the final parameter definition in any **para** command.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

You can change the definition of a parameter, and you may even include it in its own redefinition. For example, the following will first define cdat to be 0.05, and then redefine cdat to be 0.10 :

```
para  cdat 0.05;
para  cdat [2*%cd];
```

You are limited to 10000 parameter. A parameter can have up to 16 significant characters.

Editing and Syntax Checking

The data you enter into a dialogue box is checked for correctness. You will not be allowed to enter more data than what is required. If you type an opening square bracket, "[", only a valid Fortran like expression ending with a closing square bracket, "]", will be allowed. If you signal that you have finished a line by typing the "Enter" key before you have entered a valid string, the color of the cursor is changed to blue. The cursor remains solid to indicate that more data is needed.

One of the easier ways to use a dialogue box is to first choose all the options you want (if any) for the command that you have selected, and then to begin entering data. After you are finished entering the data for one line, type the "Enter" key. The solid green cursor will automatically move to the next position where data must be entered. In this way you can enter all your data without moving your hands from the keyboard.

If you want to change a string that you have already entered into the dialogue box, left-click your mouse on the place you want to change. The cursor will move there. Then you can edit the string. Three editing actions are available:

1. Type a character before the cursor position
2. Type a Backspace to delete the character just before the cursor
3. Type Control-X to delete the character beneath the cursor

If you type "Enter" while the cursor is in the middle of a string, **True*Grid*®** will behave like it does when the cursor is at the end of the string. If there is a syntax error, there will be a solid blue cursor where the error is. Otherwise, there will be a red cursor at the end of the string, hollow if there is another line of the dialogue box that needs data.

Executing and Quitting Dialogue Boxes

When you are finished entering all data in a dialogue box, you can execute it by left-clicking your mouse on the ***Exec*** (execute) button, or by typing Control-E with the mouse in the dialogue box. This works only after you have provided all the required data; that is, when you have chosen an option from every option list that requires a choice and you have entered valid strings in every line of the dialogue

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

box that needs them. When you have entered all necessary strings, every cursor in the dialogue box will be red.

When you left-click on the ***Exec*** button of a valid dialogue box, the command will be placed into the table of commands (for mesh commands), executed immediately (for database commands), or executed and the picture redrawn (for graphics commands). The ***Exec*** button will be colored red until you move the mouse, and the dialogue box will remain visible. That way you can easily reuse or modify the data you entered and execute again.

If you want to execute the command in the dialogue box and then immediately destroy the dialogue box, then left-click on the ***Exec/Quit*** button, or type Control-Z with the mouse in the dialogue box.

To quickly see the results of executing a mesh command, a 3D curve definition, or a surface definition from a dialogue box, click the Middle Mouse Button on the ***Exec*** or ***Exec/Quit*** button.

If you try to execute a dialogue box before entering all the data it needs, it will not be executed. The first incomplete line willed scrolled to the top and the prompt will be turned to blue.

At any time you can simply destroy the dialogue box. All data in it is thrown away. To do this, left-click your mouse on the ***Quit*** button, and confirm by clicking on ***yes***. Notice that the cursor is automatically repositioned on the screen for you. You may have to learn to move your mouse hand more slowly! Alternatively, type Control-Q to quit without confirmation.

Quick Reference to Keyboard Functions

These keyboard functions are explained in detail in other sections of this manual. Some of them apply only when you have selected a dialogue box.

F1	print a region or index progression selection
F2	clear region or index progression selection
F3	history window - same as ***History*** button
F4	save window configuration
F5	select a vertex, node, or control point
F6	select second vertex of a region
F7	print selected coordinates
F8	print selected label
F9	same as F8
F10	same as F10
Control-A	print a region or index progression selection
Control-B	scroll Backwards by a line

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Control-D	clear region or index progression selection
Control-E	Execute the dialogue box without quitting
Control-F	scroll Forward by a line
Control-P	toggle continuous slicing Planes on or off
Control-Q	Quit the dialogue box without confirmation
Control-U	delete text in bottom line of text window
Control-V	Verbose mode in the dialogue box
Control-X	delete the character below the curser in dialogue box
Control-Z	execute the dialogue box *and* quit or recover dialogue box

8. Interactive Construction of 3D Curves

A 3D curve is defined using the **curd** command. Alternatively, there are four curve types with interactive dialogues to help you construct a 3D curve. These interactive dialogues have the advantage that you can use all of the interactive methods in selecting points and surface edges in the case of ***COEDGE***. This includes picking points by ***Z-Buffer***, by ***Projection***, by ***Node***, and by ***Label***. The selected points and the curve connecting them will be drawn in white in the physical window as it is being constructed. Additionally, points that have been selected can be modified using the ***Move Pts.*** panel applied to the ***Point List*** (not available for ***COEDGE***). The white curve in the physical window is changed as you move the point. These interactive dialogues will generate a **curd** command which will appear in the session file (tsave). You can invoke one of these interactive dialogues from the ***3D CURVE*** menu by clicking on:

LP3 forms a polygonal curve by selecting and moving points. This produces the **lp3** option in the **curd** command when the curve is saved in the session file (tsave). This curve is not smooth and has limited applications. It is most useful when you need to extract data from existing geometry or mesh. The Point List interactive dialogue is used to create this curve.

SPLINE forms a cubic spline curve using the mouse to select and move control points. This produces the **csp3** option of the **curd** command when the curve is saved in the session file (tsave). This is probably the most important 3D curve feature and should be learned by all users. This feature produces smooth curves passing through a selection of control points that can be moved with the mouse. It is most useful when you want to shape an interior edge of the mesh. First create the spline curve. Then attach the edge of the mesh to the curve. The Point List interactive dialogue is used to create this curve. This Point List dialogue has the additional option to select the end derivatives.

TWSURF forms the intersection curve of 2 surfaces with the mouse by selecting initial points for the intersection algorithm. This produces the **twsurf** option of the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

curd command when saved in the session file (tsave). This has very little application because the projection method will project an edge of the mesh to the same intersection of two surfaces without the construction of this curve. This feature is primarily used to construct surfaces from 3D curves (see the **rule3d**, **crule3d**, **r3dc**, **pipe**, **blend3**, and **blend4** options of the sd command). The Point List interactive dialogue is used to create this curve. This Point List dialogue has the additional fields to select the surface numbers of the surfaces being intersected.

COEDGE forms a composition of smoothly connected edges of surfaces automatically. This produces the **sdedge** (**se**) option of the **curd** command when saved to the session file (tsave). If you are importing IGES surface geometry that has been broken into many small surfaces, you will typically want to build composite surfaces (see the **sds** option of the **sd** command). You may need a curve that forms the outer boundary of the composite surface so that you can attach the boundary of the mesh to the boundary of the composite surface. This features makes it trivial to construct this composite curve. The Edge List interactive dialogue is used to create this curve.

There are many features in the Point List dialogue that are common to the ***LP3***, ***SPLINE***, and ***TWSURF*** functions.

table This table contains the list of control points selected for the various types of curves. You can edit the coordinates in this table. The rules for editing a number in the table are the same as in any dialogue box. You must type the Enter key after you have modified or typed a coordinate with the keyboard for it to take affect. If the ***Insert Mode*** is checked, a table of coordinates can be pasted into this table using the mouse.

number of significant digits You can choose the number of digits displayed in the table for the coordinates in the table.

Clear All If the Point List dialogue was used previously, it may be filled with the data of a preceding curve. This button clears the table.

Confirm Selection You can choose to have each point accepted and entered into the table only after clicking on the ***Accept*** button. If this is not checked, then a point selected in the picture will be immediately entered into the table. This does not apply to points being entered into the table using the ***Insert***, ***Append***, and ***Prepend*** buttons.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Insert Mode When this is checked, any point selected in the picture will be added to the table. The placement of this new point will be after the focal point in the picture indicated with a small white square in the picture (which is also indicated with the green curser in the table). If it is not checked, than any selected point in the picture will replace the focal point.

Insert The ***Insert*** button will create a new row in the table in which to enter the coordinates of your selection. You can select a point from the picture either before or after you click on this button. You must click on ***Accept*** to have the coordinates entered into the table at this location. This insertion will be made after the focal point in the table, indicated with a small white square in the picture (which is also indicated by the green curser in the table). You can also choose the focal point and insertion by editing the sequence number into the field next to the word **after** and then typing the Enter key. The new inserted point becomes the new focal point. The insertion also causes the **Insert Mode** to be checked.

after The field next to this word is constantly maintaining the sequence number of the focal point in the table. The focal point is the point enclosed by a small white square in the picture. It is also indicated by a green curser in the table. When a point is inserted, it is after the focal point and the new point being inserted becomes the focal point. There are several ways to choose the focal point. Move the mouse close to a point in the picture and click on the **F5** key. Or, click on the row in the table corresponding to the point you wish to focus on. The up and down arrows in the keyboard will scroll through the points in the table to choose the focal point. You cal also enter the sequence number of the point you wish to be focal.

Append This button will create a new row at the end of the table. You can select a point from the picture either before or after you click on this button. After selecting a point, click on the ***Accept*** button to have the point added at the end of the table. You can select the first point in the table using the **F5** key with the mouse near this point in the picture. Upon accepting this point, you will close the curve. The new inserted point becomes the new focal point. The insertion also causes the **Insert Mode** to be checked.

Prepend This button will create a new row at the start of the table. You can select a point from the picture either before or after you click on this button. After selecting a point, click on the ***Accept*** button to have the point added at the start of the table. You can select the last point in the table using the **F5** key with the mouse near this point in the picture. Upon accepting this point, you will close

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

the curve. The new inserted point becomes the new focal point. The insertion also causes the **Insert Mode** to be checked.

Accept This button is used after ***Insert***, ***Append***, or ***Prepend*** and after having selected an associated point. This button enters the coordinates of the selected point into the table. If **Confirm Selection** has been checked, then every point must be accepted using this button before its coordinates are entered into the table.

Delete When this button is clicked, the points in the table identified by the range of sequence numbers in the **from** and **to** fields will be deleted from the table. If no numbers are indicated, then the focal point is deleted.

from This field is the start of the range of sequence numbers of points to be deleted from the table when the ***Delete*** button is clicked.

to This field is the end of the range of sequence numbers of points to be deleted from the table when the ***Delete*** button is clicked. If this field is left blank, only one point will be deleted from the table.

Save This button is used to save the curve as a standard curve in the internal 3D curve database. This also causes an equivalent **curd** command to be printed to the session file (tsave).

Quit This causes the Point List window to disappear. It does not clear the points in the table.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Create a Polygonal Curve Interactively

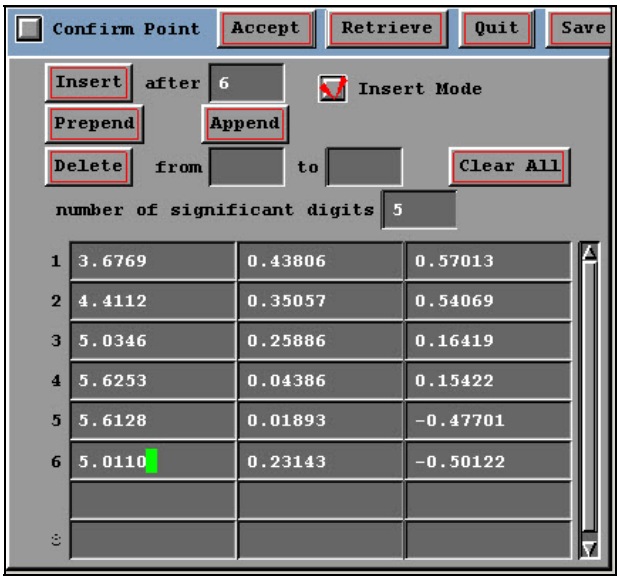


Figure 167 Interactive Form for Polygon Input

You can select points by using options from the ***Pick*** Panel. For example, select a surface, curve, or surface edge and click on the ***Projection*** button. Each time you click in the physical window, an point will be added to the table and the white curve drawn in the physical window will be extended to this new point. Similar steps with the ***Z-buffer***, ***Label***, or ***Node*** buttons in the ***Pick*** panel will add points to the table.

The following picture represent gradual steps in defining a polygonal curve. The surface points have to be labeled. Then they are selected using the ***Label*** option in the ***Pick*** panel. The Mouse Pointer is moved to the location of the new point and the Left Mouse Button is pressed. The coordinates of the new point are inserted to the next location in the interactive form. If you need a more detailed picture, use the ***Zoom*** or ***Frame*** display options. After finishing the input you have to save the curve by pressing the ***Save*** button.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

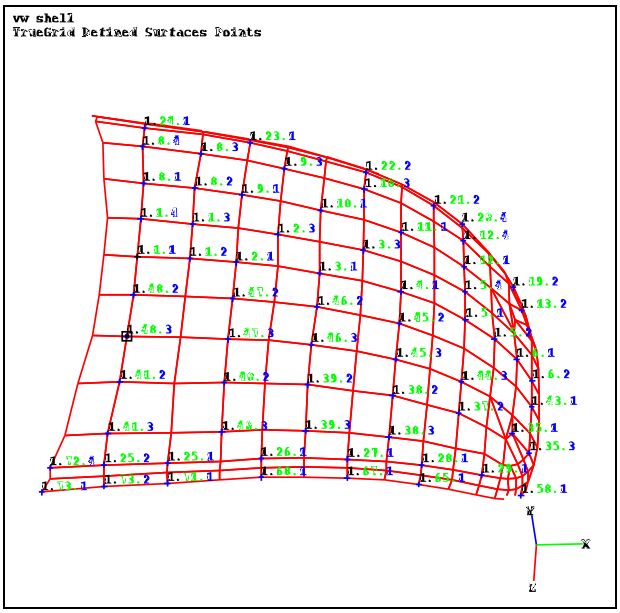


Figure 168 Step 1

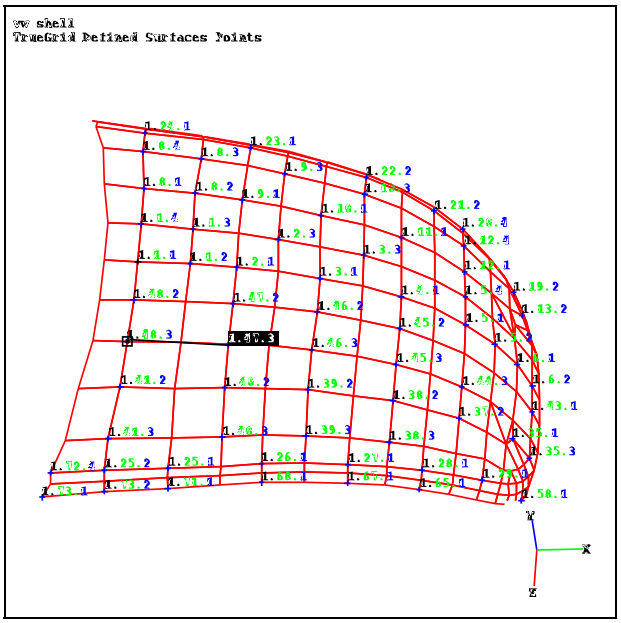


Figure 169 Step 2

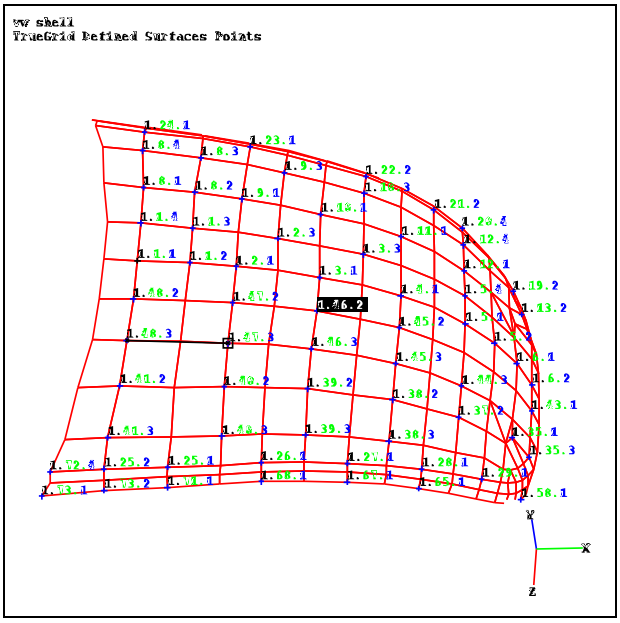


Figure 170 Step 3

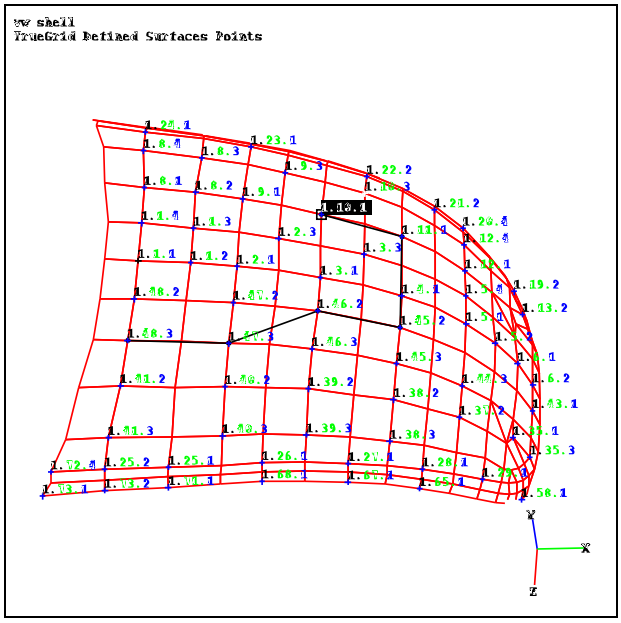


Figure 171 Step 4

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

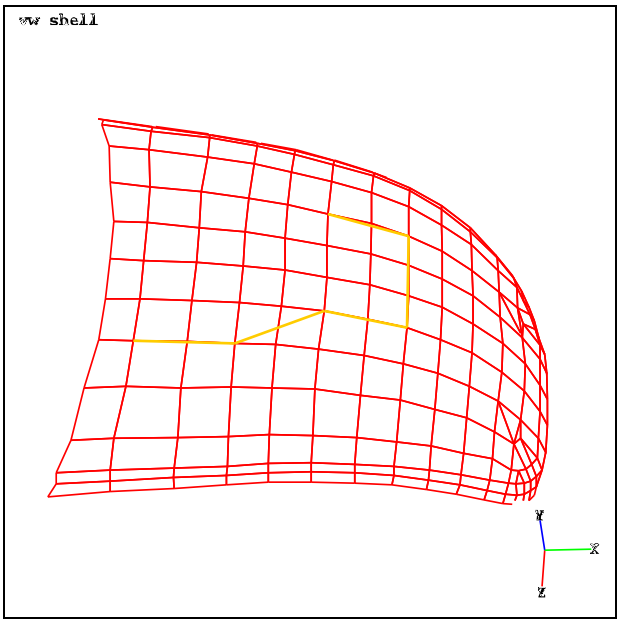


Figure 172 Polygonal Curve

How to Create a Spline Curve Interactively

You can select points (sometimes referred to as control points of a cubic spline curve) by using options from the ***Pick*** Panel. For example, draw the picture in ***Hide*** or ***Fill*** graphics mode. Then select the ***Z-Buffer*** option in the ***Pick*** panel. Each time you click on a point in the picture, a point will be entered into the table and the white curve drawn in the physical window will be extended to this new point. Similar steps with the ***Projection***, ***Label***, or ***Node*** buttons in the ***Pick*** panel will add points to the table.

The following pictures represent gradual steps in the definition of the cubic spline control points. The Mouse Pointer is moved to the location of the new point and the Left Mouse Button is pressed. The coordinates of the new point are inserted to the next location in the interactive form.

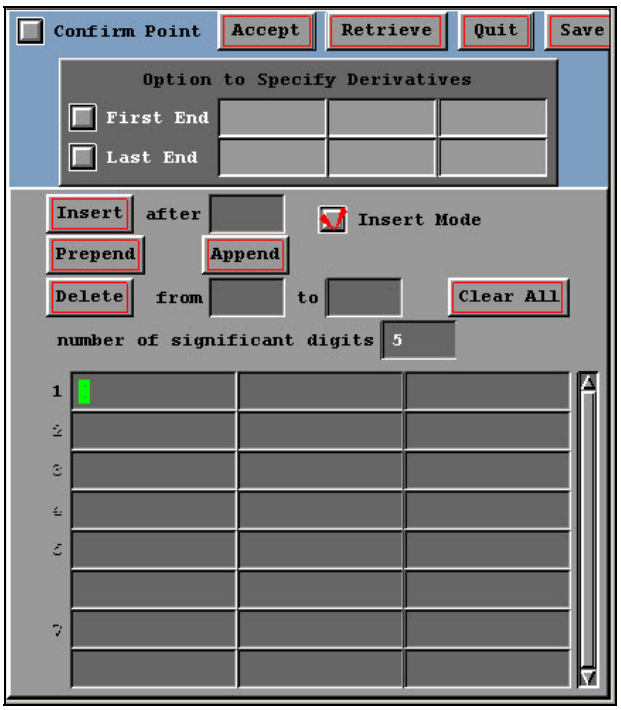


Figure 173 Spline Point List dialogue

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

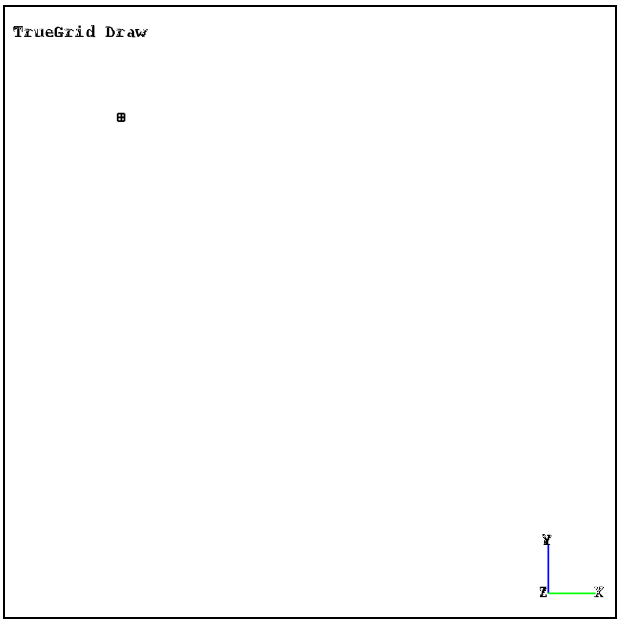


Figure 174 Step 1

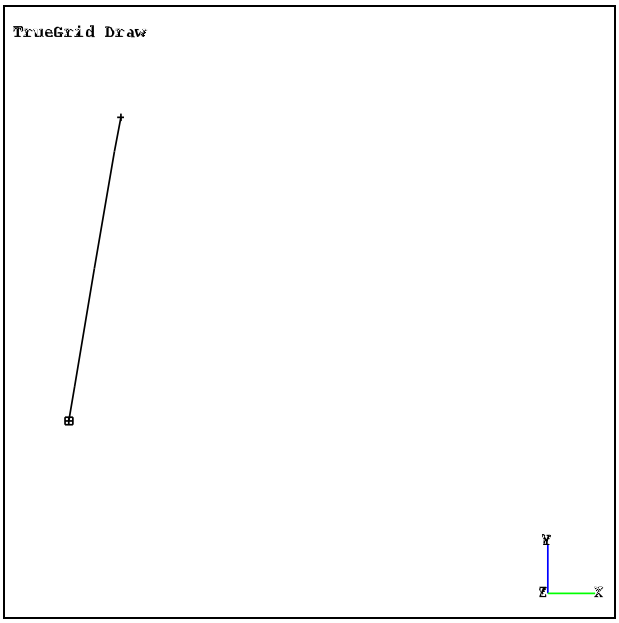


Figure 175 Step 2

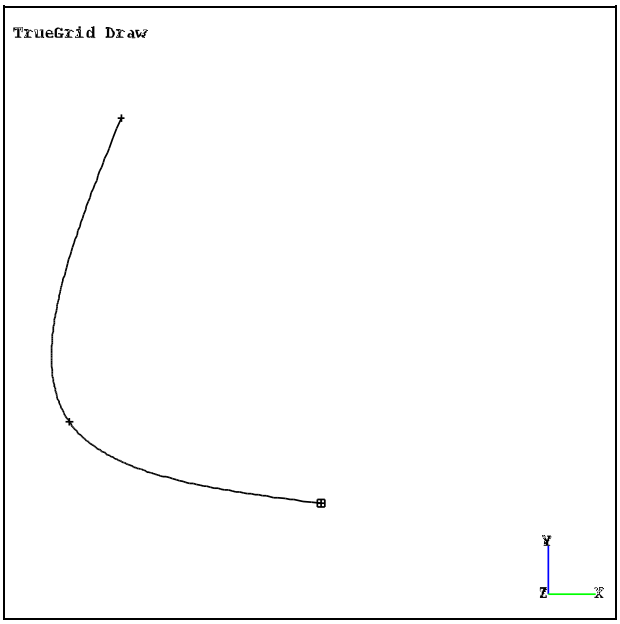


Figure 176 Step 3

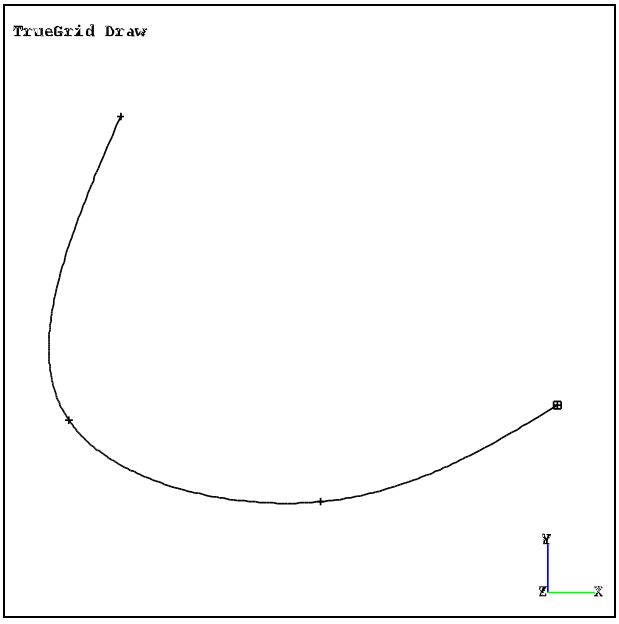


Figure 177 Step 4

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Controlling the End Derivatives of a Spline

After all of control points have been selected, a 3D cubic spline still has 6 degrees of freedom which are usually consumed by requiring that the second order end derivatives be set to zero. This is the default and is referred to as the natural derivatives. Alternatively, you can choose the first derivatives at the start and/or end control points. Check either or both boxes for the derivatives. Then enter the end derivatives following the rules for entering and modifying data in a dialogue box. Be sure to type Enter to complete your entry for each component of the derivatives.

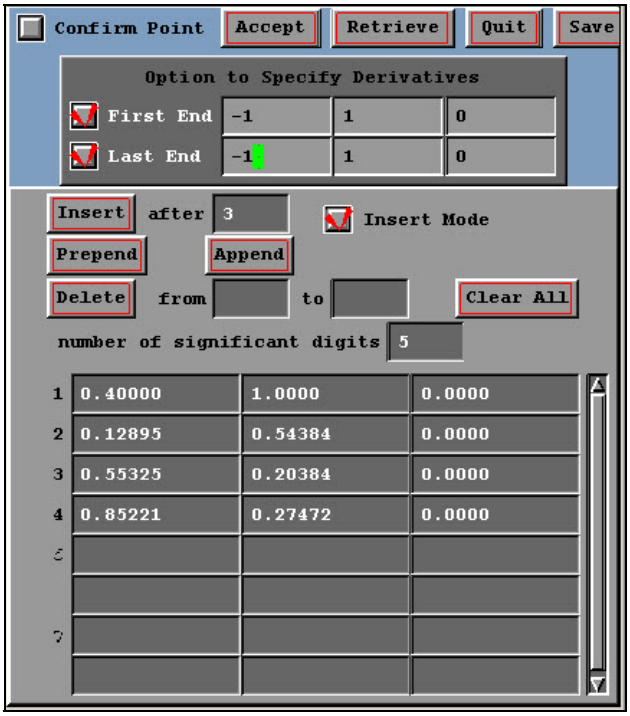


Figure 178 Control of End Derivatives

After finishing the input, you have to save the created curve by pressing the ***Save*** button.

The next picture shows the difference between the shapes of curve with natural derivatives (curve 1) and curve with specified end derivatives (curve 2). The end derivatives are vectors whose magnitude will have an effect on the shape of the curve.

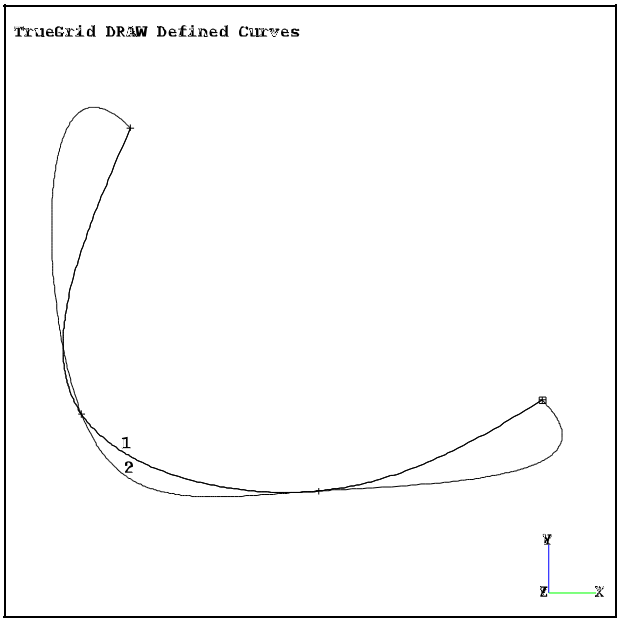


Figure 179 Control of End Derivatives

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Inserting a Cubic Spline Control Point

Before a new control point can be added, its position in the sequence of control points must be selected. This is done by selecting one of the existing control points as the focal point. Insertion is made in sequence after the focal point. There are five methods to select the focal point.

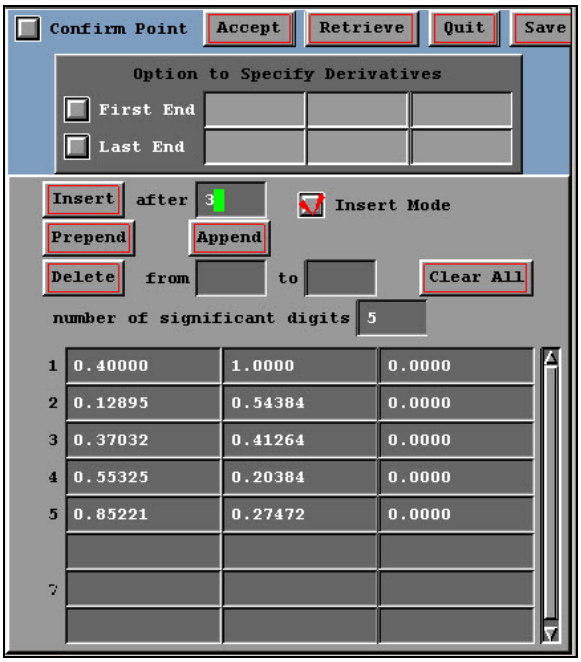


Figure 180 Insertion of a Control Point

Method 1 - Scroll through the control points with the keyboard arrow keys. The mouse must be in the Point List or Physical window. As you scroll, you will see a small box in the Physical Window move from one control point to another.

Method 2 - Click on the row of the desired control point with the Left Mouse Button.

Method 3 - Move the Mouse Pointer close to the control point in the picture and type the **F5** function key.

Method 4 - Enter the control point sequence number in the field after the Insert button. Either type the Enter key or click on the ***Insert*** Button.

Method 5 - Click on the ***Prepend*** or ***Append*** button which moves the focal point to the first or last position in the table, respectively, and prepares a new row for data entry.

Now you can select a point in the picture in order to add a new control point. If you have clicked on ***Prepend*** or ***Append*** button, you must also click on accept.

In this example, the second control point of curve 1 was selected as the focal point and a new control point was inserted after the second point to create curve 2. Any additional control points will continue to be added after this new one until a new focal point is selected.

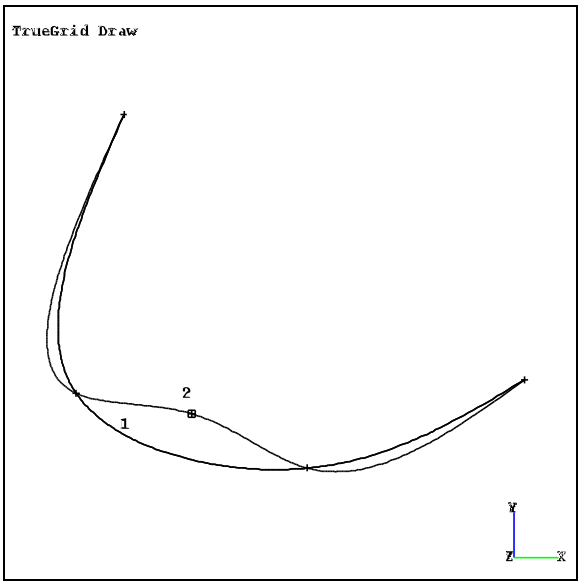


Figure 181 Insertion of a Control Point

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Deleting Cubic Spline Control Points

There are two ways to select control points in the Point List table for deletion.

Method 1 - Before a control point can be deleted, it must be selected as the focal point. The various methods are described above.

Method 2 - Enter the sequence numbers of the control points into the **from** and **to** fields next to the ***Delete*** button.

Click on the ***Delete*** button. Alternatively, you can delete all of the control points by clicking on the ***Clear All*** button.

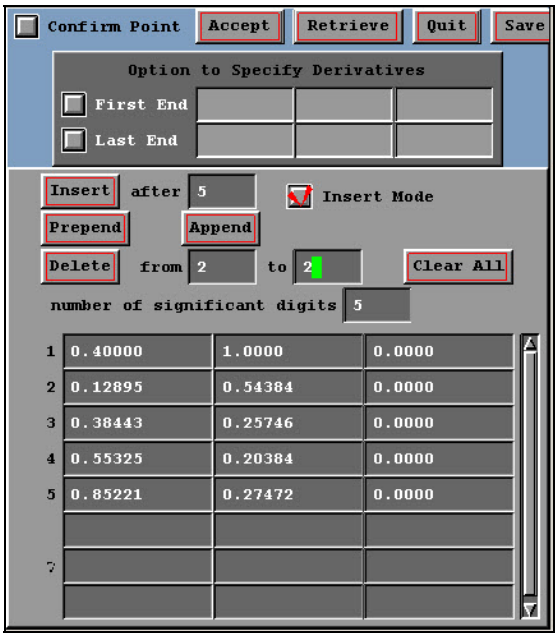


Figure 182 Deletion of a Control Point

In this example, the second control point of curve 1 was selected and deleted from the Point List to create curve 2.

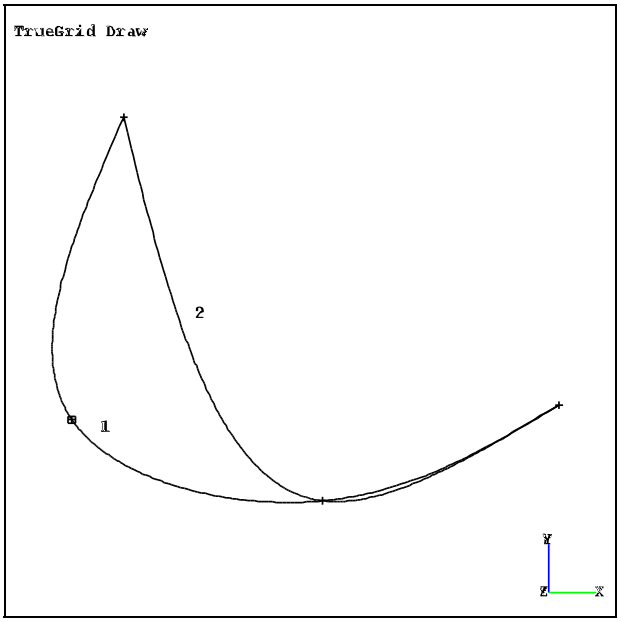


Figure 183 Deletion of a Control Point

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Moving a Cubic Spline Control Point

Choose the control point to be moved by selecting the control point to be the focal point. This step is described above.

There are two methods to move the focal point.

Method 1 - Select the ***Move Pts.*** button of the Environment Window and then select the ***Point List*** option. Now select one of the methods under the label **Constrain to**. With the Left Mouse Button click and drag in the Physical Widow to move the control point to a new location.

Method 2 - Turn off ***Insert*** mode. Choose one of the ***Pick*** panel point selection options: ***Projection***, ***Z-buffer***, ***Label***, or ***Node***. Pick a point using this selected method.

In this example, the second control point of curve 1 is moved in the x and y direction into a new location to create curve 2.

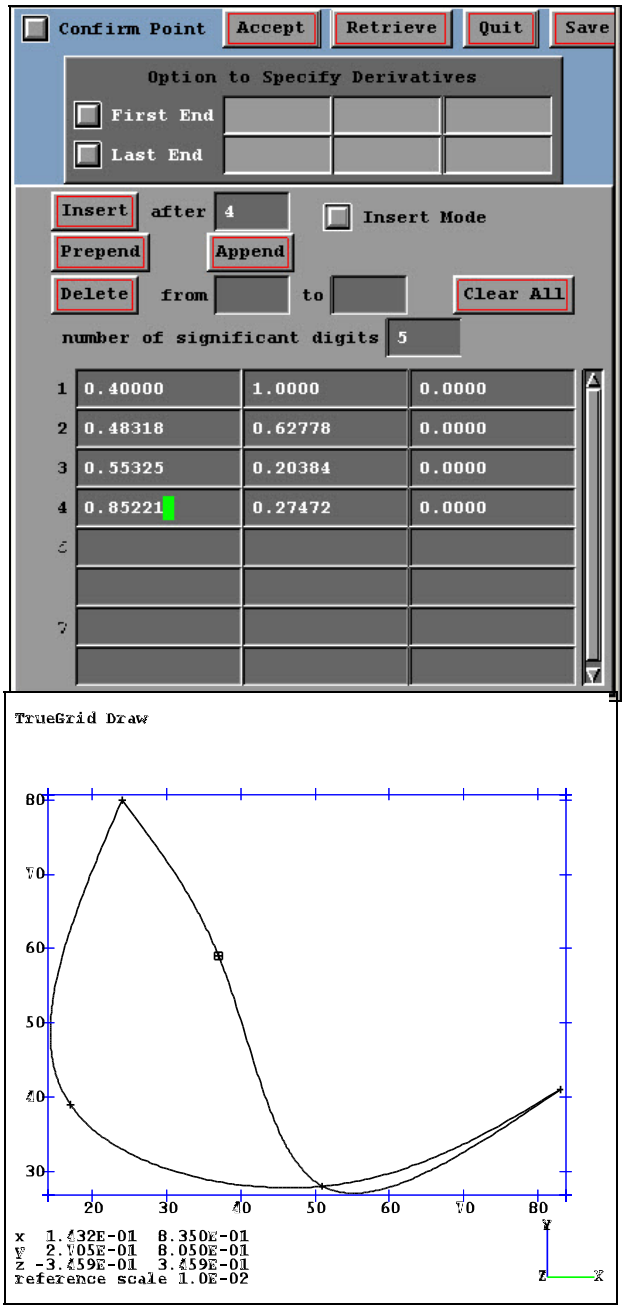
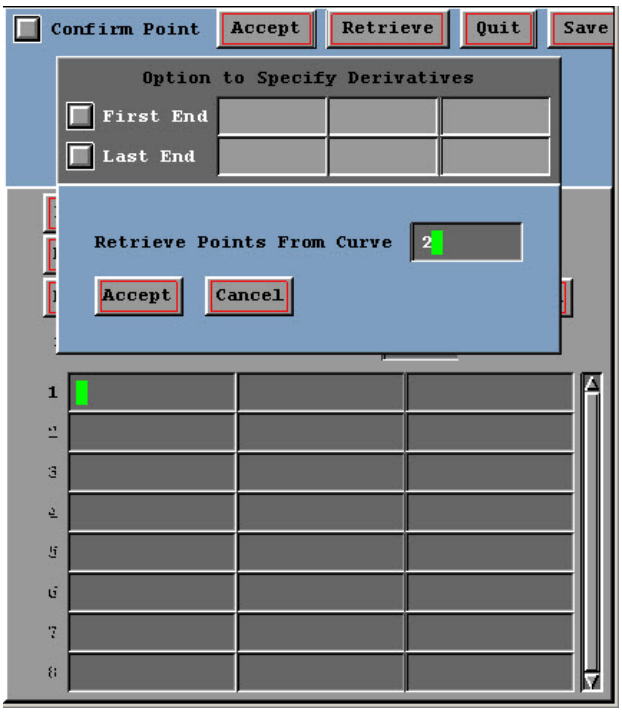


Figure 185 Movement of a Control Point

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Retrieving 3D Cubic Spline, Polygonal, or Intersection Curve

If you wish to modify a 3D curve you previously created using the points list window (Spline, LP3, or Twsurf) then, first, clear the points list by clicking on the Clear All button and then click on the Retrieve button at the top of the Points List window. In the window that pops up, enter the 3D curve number to be retrieved. Then click on the Accept button. Now use the different methods to change the 3D curve. When you are satisfied with the new curve, click on Save to save the new curve by what ever number you want to choose. This method works on all three types of interactive 3D curves.



Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Creating the Intersection of Two Surfaces

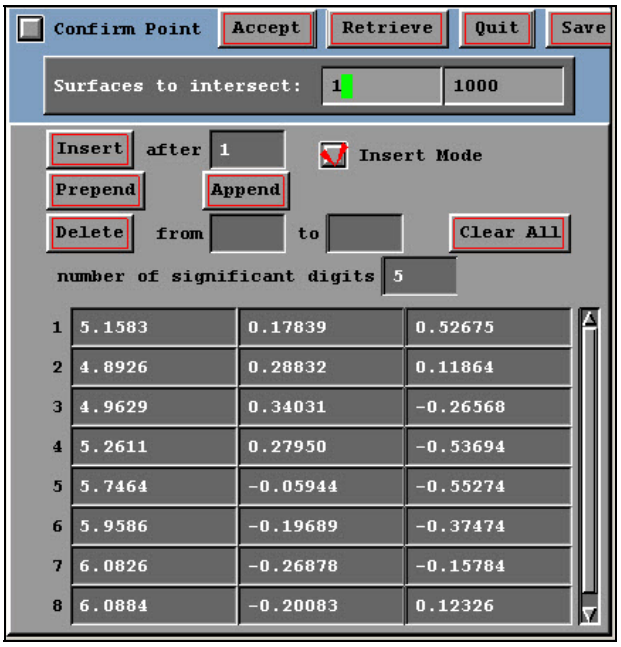


Figure 187 Curve of Intersection

The method used to intersect two surfaces requires an initial approximate intersection curve formed by a polygonal line. You need to select a sequence of points that are near the intersection of the two surfaces. More points are needed near greater curvature. You will need about 1 point every 120 degrees of curvature. If the curve of intersection has a small amount of curvature, you may only need to select a starting and ending point. These points do not need to be at the intersection of the two surfaces, just close enough that the projection algorithm will converge to the intersection of the surfaces.

The selection of points with this type of curve creation is the same as in other curve creation types that use the Point List. However, the ***Z-Buffer*** option is preferred because you can display just the two surfaces of intersection and easily pick off coordinates near their intersection. The following pictures demonstrate the steps used to create the intersection of a polygon surface and a cylinder. This example used the ***Prepend*** and ***Accept*** buttons to close the polygon line, causing the refined curve to be closed as well.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

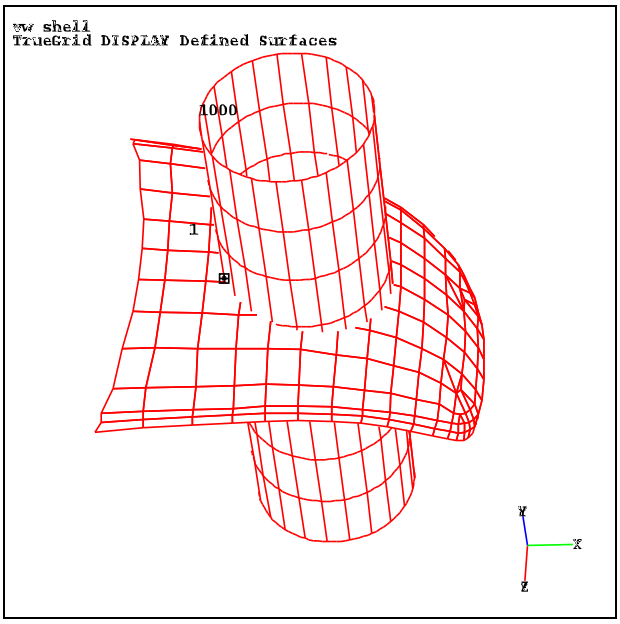


Figure 188 Step 1

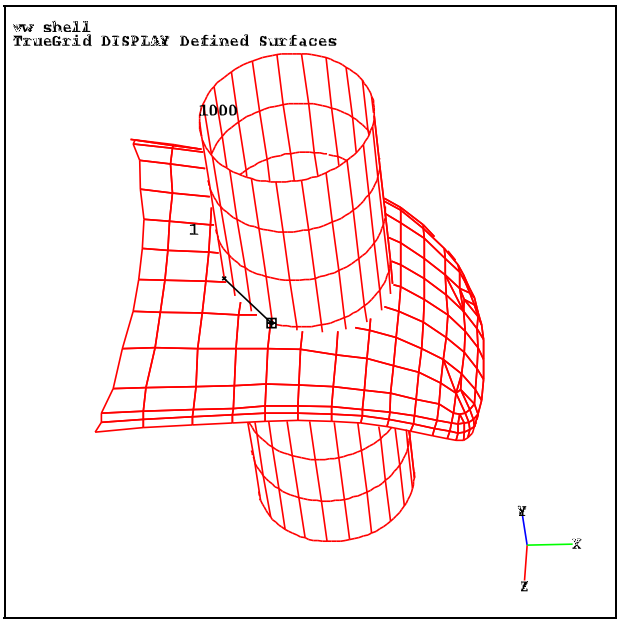


Figure 189 Step 2

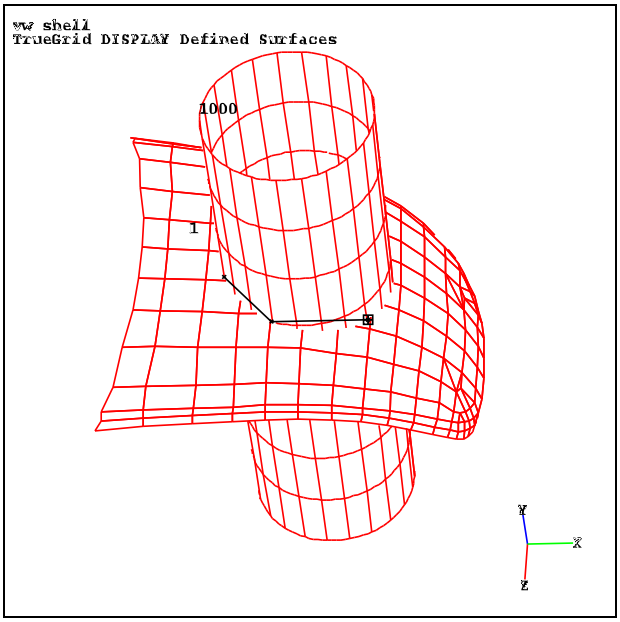


Figure 190 Step 3

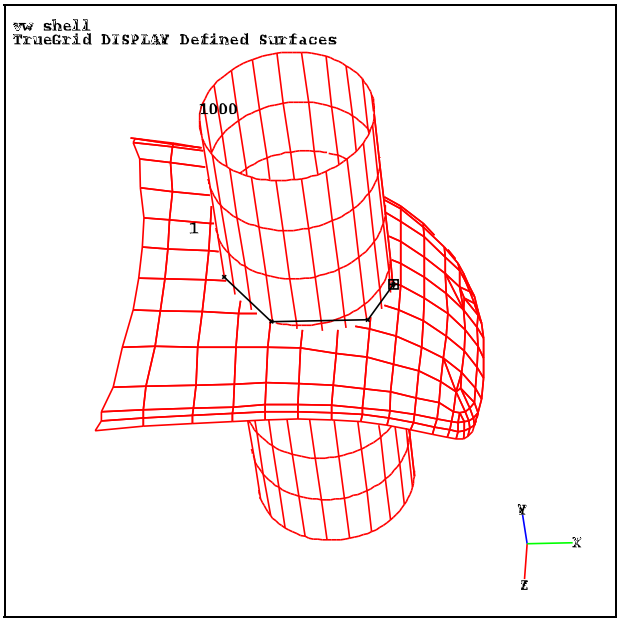


Figure 191 Step 4

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

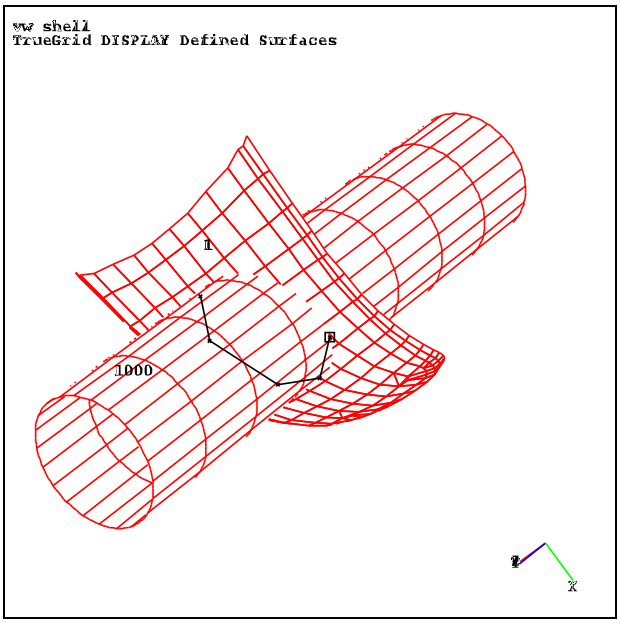


Figure 192 Step 5

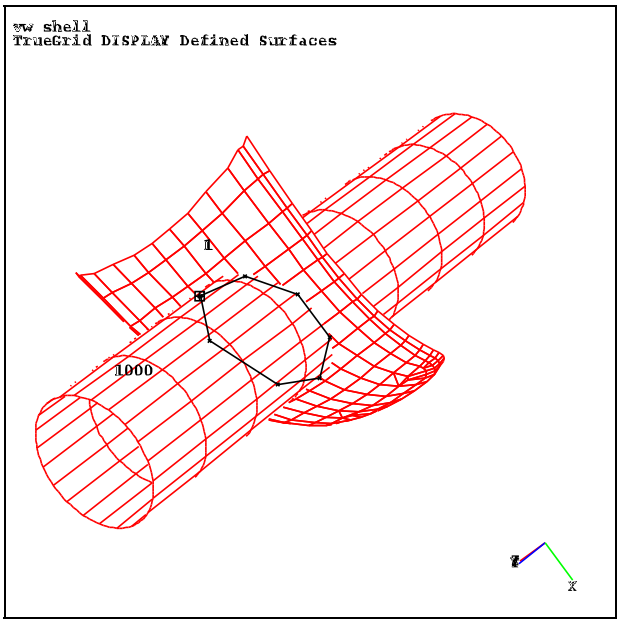


Figure 193 Step 6

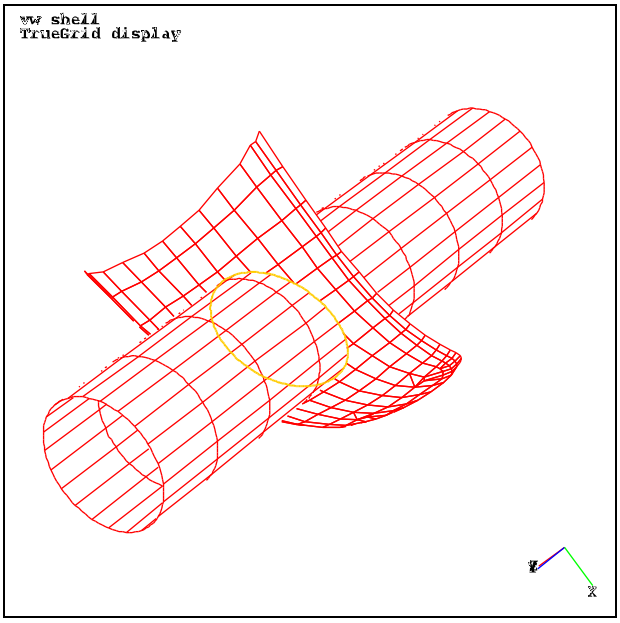


Figure 194 Step 7

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Interactive Composite Curve from Surface Edges

This tool is meant to be used when there are many surfaces, such as a large model from an IGES file. Typically, many surfaces are combine into one composite surface using the **sd** command with the **sds** option. In order to cover these surfaces with a mesh, it may be necessary to create a bounding 3D curve. Then the edges of the mesh can be attached to this curve. With the ***COEDG*** (COmposite EDGe) feature, edges of the surfaces are selected in sequence to form a composite curve. The same thing can be accomplished by using the **se** or **sdedge** option of the **curd** command many times. The result of this interactive tool is a 3D composite curve which is recorded in the session file (tsave) using the **curd** command with the **se** option. This tool can simplify the procedure of building a composite curve and cut down on the time significantly.

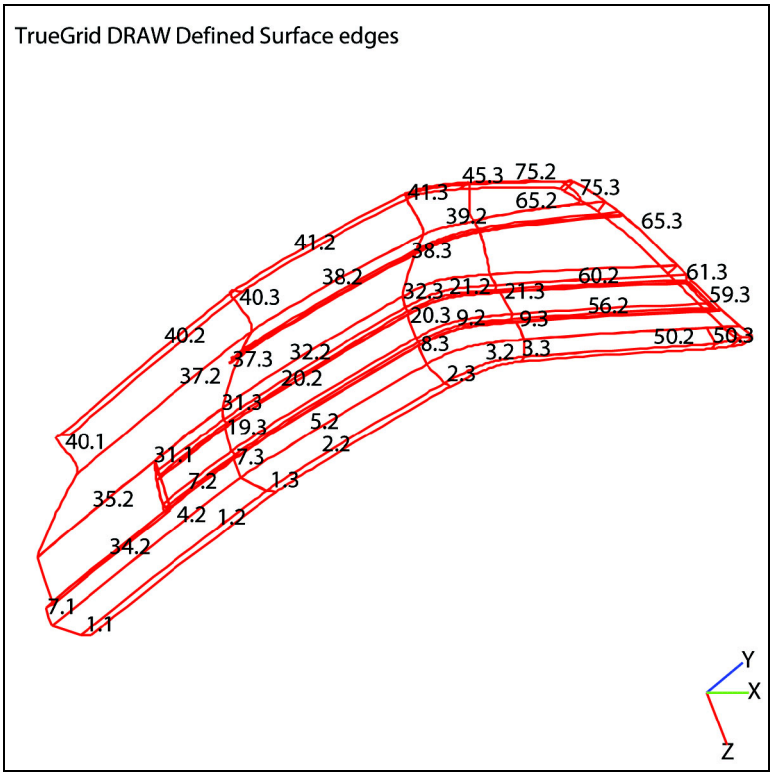


Figure 195 Many surfaces with edges labeled

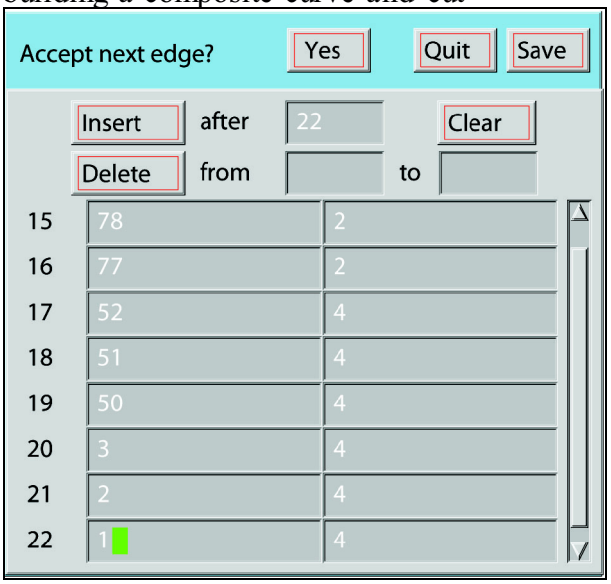


Figure 196 ***COEDG*** window

To activate this feature, go to the ***3D Curves*** menu and click on the ***COEDG*** button. Display the surfaces with the **sdint off** command so that the surface interior lines are not shown. Then label the surface edges and choose ***Label*** under the ***Pick*** panel in the environment window.

The first step is to select the first surface edge. Based on this selection, the next likeliest surface edge in the picture will be highlighted. If this is the next desired edge, then the ***Yes*** button should be clicked on. Otherwise, an alternative must be selected. This process continues until all of the desired edges in the proper order have been

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

selected. If the likeliest next edge is always the desired next edge, one can create such a composite curve very quickly simply by clicking on the ***Yes*** button for each component.

If a wrong edge is selected, it can be deleted. For example, if the last edge selected was wrong, not only will the wrong edge be appended, but the next one will be highlighted for selection. First click on the ***Delete*** button in the **COEDG** window. Then move the mouse to the picture and select the appropriate edge by clicking on its label. You may have to zoom or frame in to see the label. After repairs are made, continue as before.

A sequence of edges can be selected by type the first and last sequence numbers of the edges and them click on the ***Delete*** button. You can click on one of the rows and then click the ***Delete*** button to delete that one edge.

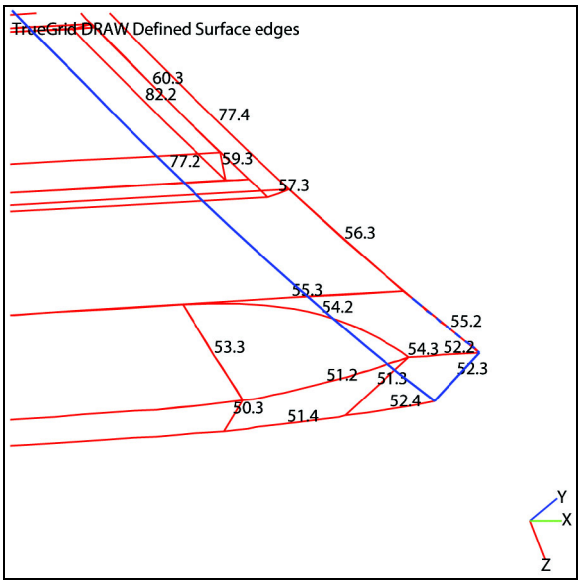


Figure 197 Zoom in to get the correct edge

You can also insert an edge by selected the edge that precedes the one to be inserted. Then click on the label of the edge to be inserted.

If the automatic selection cannot determine the next curve or if there are no more edges to be selected, it will not make a next likeliest choice.

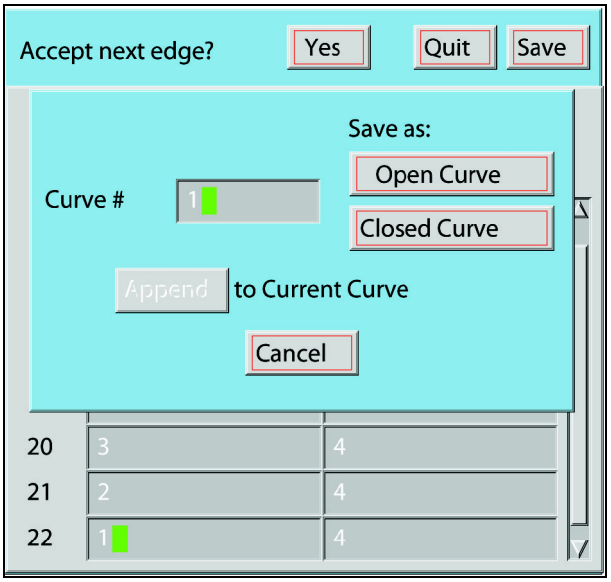


Figure 198 Save as curve 1

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

When all edges have been selected, save the curve. Click on the ***Save*** button. Then fill in the curve number to be assigned to this curve. In most cases, to complete the saving of the curve, click the ***Open Curve*** button. If you wish for the two ends of the curve to meet, click on the ***Close Curve*** button instead.

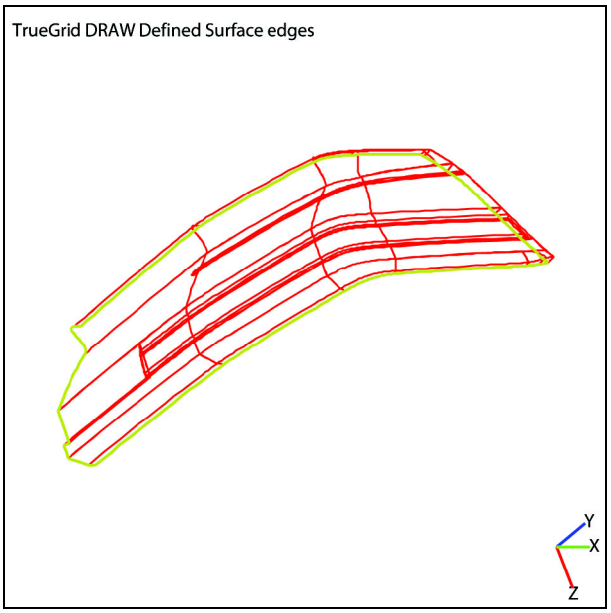


Figure 199 Composite curve

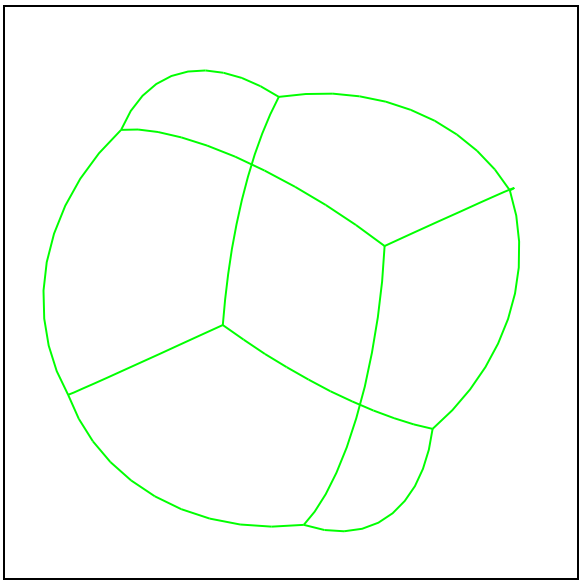
Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

III. Part Commands

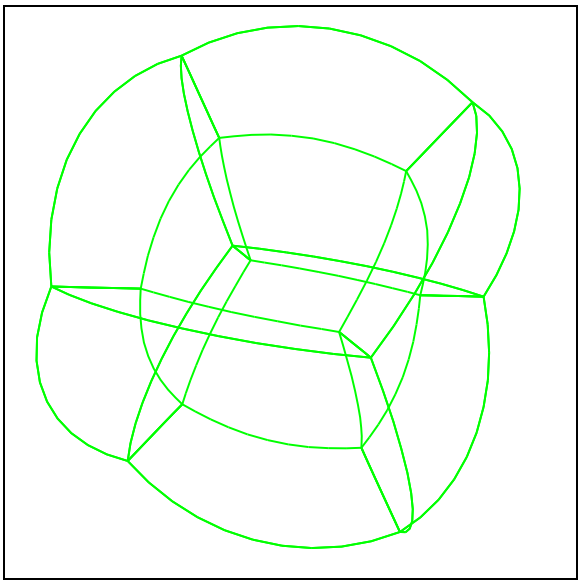
Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

1. Geometry and Topology

The topology of the mesh refers to the way a geometry is decomposed into blocks. There are many ways to do this for even the simplest of geometries. For example, you can use a single block to form the shape of a sphere but the result would be very poor because there would be elements that have very large and very small angles. The better approach is to use 7 blocks to form what is referred to as a three dimensional butterfly topology. This produces the best angles in the elements. Obviously, the choice in topology is critical to producing a good mesh.



Single block topology



Multiple block topology

In a multi-block topology, you can build each block as a separate part. Then you must take care that the blocks meet. This would not be taking advantage of the full capabilities of **True*Grid*®** and you will be inefficient. Alternatively, you can build multi-block parts. Then many of the steps you took to make sure the blocks matched at the interfaces will not be needed. For example, the multi-block mesh of the sphere above was created with one part. With experience, you will learn when to use a single part with multiple blocks and when to break a geometry into multiple parts. Some power users of **True*Grid*®** will try to use the least number of parts for a topology. Such elegant solutions can lead to a slight increase in complexity, but justified by the profound increase in productivity.

You can specify the topology of a single part with the **block** and **cylinder** commands. In each of these commands you specify **i**, **j**, and **k** index lists. The number of nodes or elements assigned initially to each of the blocks in either the **block** or **cylinder** command can be refined at any time afterwards using

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

the **mseq** or **lmseq** command. Blocks can be split into two, anytime, using the **insprt** command. Then the **de** and **dei** commands can carve out holes in the part, forming exactly the block topology that you need.

The rest of the information needed to fully describe the shape of the mesh, after the topology has been specified, is the model geometry. You begin to specify the geometry of a part with the coordinate lists in the **block** and **cylinder** commands. Then the **pb**, **pbs**, **mb**, **mbi**, **q**, **tr**, **tri**, **ilin**, **ilini**, **cur**, **cure**, **curs**, and **edge** commands are used to modify this shape.

Edges, faces, and interior nodes are automatically interpolated. Interpolation commands such as **lin**, **lini**, **splint**, **tf**, **tfi, relax**, **relaxi**, **esm**, **unifm**, **unifmi**, **tme**, and **tmei** can override this default interpolation. In practice, one uses these commands to generate a higher-quality mesh.

You can constraint parts of the mesh by projecting a region of the mesh to a surface with the **sf**, **sfi**, **patch**, **ssf**, and **ssfi** commands, gluing a region of the mesh to another part using the **bb** or **trbb** commands, and placing an edge of the mesh permanently onto a 3D curve with the **curf** command.

Each time a mesh generation command is issued and the mesh redrawn, the mesh is recalculated. This is done because the set of surface projections are treated as a system of constraints that must be solved simultaneously. One change in the list of constraints can have a global effect. Since the constraints are satisfied simultaneously, the order in which they are issued is of no consequence. The order in which the mesh generation commands are applied to the mesh (known as the Command Hierarchy) is the key to understanding the projection method which is the heart of **True*Grid*®**. This order of execution is:

1. Initialize. There are three types of initialization:
   i) **block** and **cylinder** commands can contain initial coordinates of the vertices.
   ii) Slave side of **bb** and **trbb** initializes and freezes block interface nodes.
   iii) **pb**, **mb**, **pbs**, **q**, **tr**, and **ilin** commands initialize vertices.
2. Apply specified interpolation of edges along 3D curves (**cur**, **curf**, **curs**, **cure**, **edge**, **splint**, **patch**)
3. Project vertices to specified surfaces (**sf**, **ms**, **ssf**, **spp**).
4. Apply specified edge linear interpolations (**lin**).
5. Apply default edge linear interpolations.
6. Project edges to specified surfaces (**sf**, **ms**, **ssf**, **spp**, **patch**).
7. Apply specified bi-linear interpolations of faces (**lin**).
8. Apply default modified bi-linear interpolation of faces.
9. Project faces to specified surfaces (**sf**, **ms**, **ssf**, **spp**).
10. Perform transfinite interpolation of specified faces (**tf**).
11. Apply equipotential relaxation of specified faces (**relax** and **esm**).
12. Apply Thomas-Middlecoff elliptic solver for specified faces (**tme** and **unifm**).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

13. Re-interpolate and project edges and faces affected by 11, 12, and 13 above.
14. Apply specified tri-linear interpolation of solid regions (**lin**).
15. Apply default modified tri-linear interpolation of solid regions.
16. Perform transfinite interpolation for specified solid regions (**tf**).
17. Apply equipotential relaxation for specified solid regions (**relax**).
18. Apply Thomas-Middlecoff elliptic solver for specified solid regions (**tme**).
19. Apply uniform smoothing elliptic solver for specified solid regions (**unifm**).
20. Evaluate expressions (**x=**, **y=**, **z=**, **t1=**, **t2=**, **t3=**).
21. Apply block boundary interface - master side (**bb**).

de delete a region of the part

de *region*

Remarks

Typically one first defines multiple regions with a **block** command, and then deletes a few of them with **de** or **dei**. When you delete regions, the 2D and 3D elements within the specified regions become undefined. Condition and properties are not applied to these regions. The elements in these regions will not appear in the graphics, merging phase, or in any output.

dei delete regions of the part

dei *progression*

Remarks

See the remarks on the previous command, **de**. In general, an "i" after a command indicates that the command takes an index progression as its argument, instead of a region.

insprt insert a partition into the existing part

insprt *sign type index #_elements*

where

sign can be:

1	for a solid
-1	for a shell

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

type can be:

1	for i-partition to the left
2	for i-partition to the right
3	for j-partition to the left
4	for j-partition to the right
5	for k-partition to the left
6	for k-partition to the right

index is the place to insert the partition (reduced index) and must be between 1 and the total number of reduced indices in the direction to be modified

#_elements must be positive, and lower than the number of elements in the region.

Remarks

This command allows you to interactively modify the block topology by adding a new partition. The partition may be a regular partition or a shell partition. Adding a regular partition results in the same block structure as would result from adding another positive number to the **block**, **blude**, or **cylinder** command. Adding a shell partition is the same as adding a new negative number to the **block** or **cylinder** command.

You locate the new position of a partition by specifying a reduced index and direction (left/right), and the number of elements from that partition. We use the terminology 'left of a partition' to mean that the partition will be located at a smaller index than the given partition. You must, of course, specify whether the new partition should be an i-, j-, or k-partition.

It is perfectly valid to grow the mesh with this command. That is, you may specify a number of nodes to the right of a maximum-index partition, or a number of nodes to the left of a minimum-index partition. When a partition is added between existing partitions, the new vertices remain in the same position as the old vertices. When a partition is added to the left of the first partition or to the right of the last, then the new vertices are initialized to the same location as the corresponding vertices on the first or last partition, respectively. So the new regions appear to be collapsed to the old regions.

All of the commands issued up to the point of the insertion are adjusted appropriately. In fact there is only one subtle difference between the mesh before and after the insertion of an internal partition: When blocks are split, new degrees of freedom are introduced. Default interpolation only applies to a single block. Therefore, if only default interpolation applies to the blocks that are split, then these blocks will be different. The original mesh is obtained by issuing **lini** (**tfi** if the default has was specified using the **intyp** command) commands for all single faces split by the new partition, and for the single blocks split by the new partition. If other than default interpolation was used for these faces and blocks, then the new mesh will be identical.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This command offers a convenient way to add regions for boundary conditions, or to add features to a mesh. Features may be internal, or a new mesh can be added to a part in this way. There is a tremendous advantage in that the new vertices are automatically initialized in a reasonable way. Thus, you are spared the trouble of finding locations for such vertices. Hundreds of blocks can be created this way by starting with only a handful of blocks.

Example - Adding a Partition in the Middle of the Block

```
block 1 5 9 13; 1  2   3   4; 1 3 5 7 9;
      1 3 5  7; 0 .7 1.4 2.1; 1 3 5 7 9;
insprt 1 1 3 2
```

The new partition is inserted to the left of i-index 3

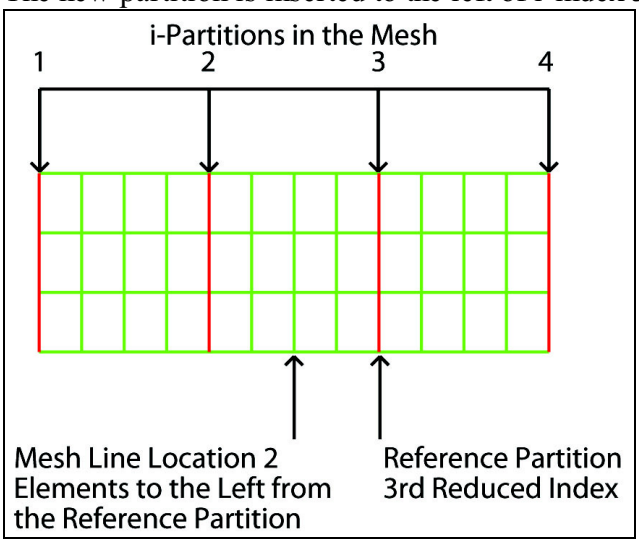


Figure 202 Block Mesh before insprt

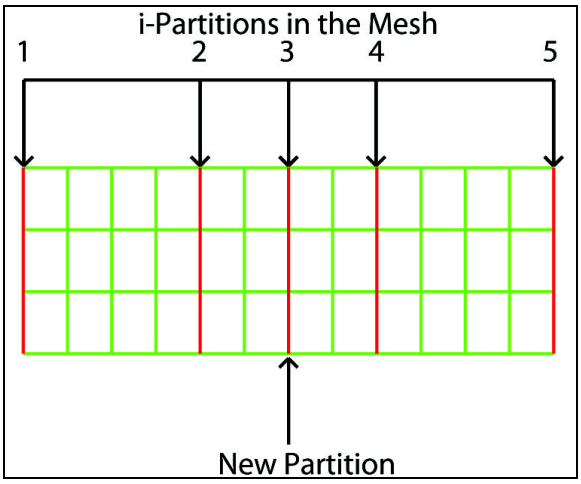


Figure 203 Block Mesh after insprt

Example - Adding a Partition at the Beginning of the Block

```
block 1 5 9 13;1 2 3 4;1 3 5 7 9;1 3 5 7;0 .7 1.4 2.1; 1 3 5 7 9;
insprt 1 1 1 2 pb 1 1 1 1 4 5 x -2
```

The new partition is inserted to the left of the reduced index 1 in the i-direction. The size of the partition is 2 elements. The new region, `1 1 1 1 4 5`, is then moved by the **pb** command -2 units in the x-direction.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example - Adding a Partition at the End of the Block

```
block 1 5 9 13; 1  2   3   4; 1 3 5 7 9;
      1 3 5  7; 0 .7 1.4 2.1; 1 3 5 7 9;
```

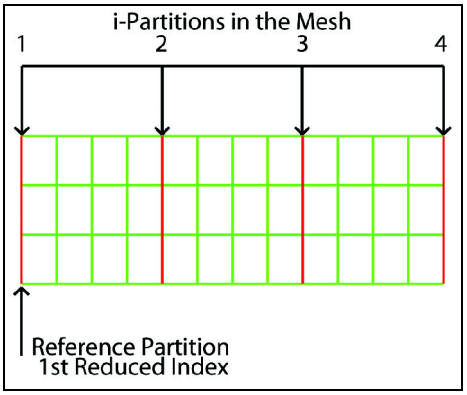


Figure 204 before insprt & pb

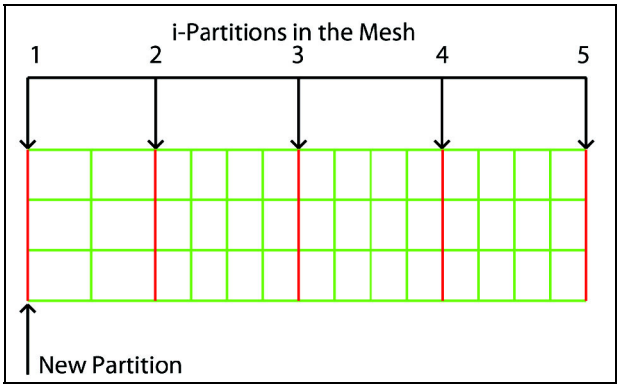


Figure 205 after insprt and pb

```
insprt 1 2 4 2 pb 5 1 1 5 4 5 x 10
```

The new partition is inserted to the right of the reduced index 4 in the i-direction. The size of the partition is 2 elements. The new region , `5 1 1 5 4 5,` is then moved by the **pb** command a distance of 10 units in the x-direction.

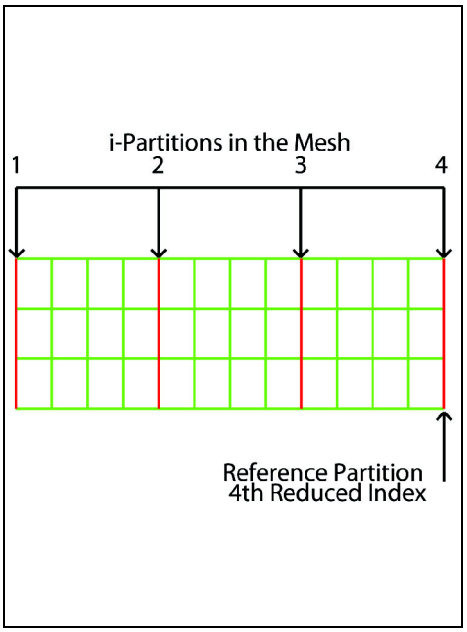


Figure 206 before insprt & pb

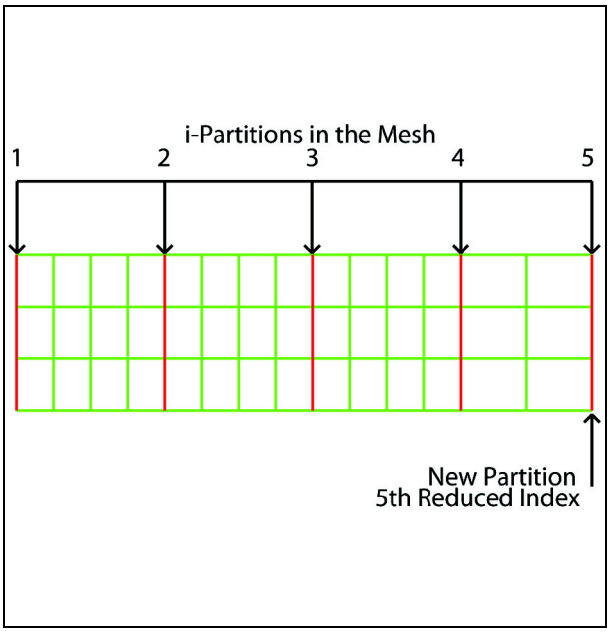


Figure 207 after insprt and pb

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

lmseq change the number of elements in a block

lmseq *direction left_partition δ*

where

direction	is **i**, **j**, or **k** direction
left_partition	is the index of the partition on the left side of the region being changed
δ	is the increment in the number of nodes within the region in the specified index direction.

mseq change the number of elements in the part

Change the number of elements that was originally specified with the i-, j-, or k-sequence in a **block**, **blude**, or **cylinder** command.

mseq *direction* d_1 d_2 ... d_n ;

where

direction	is **i**, **j**, or **k**, and there is one d_m for each of the regions in the specified index direction. Each d_m is a change in the number of nodes for the m-th region.

Remarks

This command is useful when the part is initially very coarse. After the geometry and the projections are specified interactively, then you can use this command to experiment with the number of nodes needed for the desired mesh. This is a natural way to proceed, since working in this way tends to minimize the amount of required computations while the major structure of the mesh is being specified.

Do not use this command after using the **update** command or the equations **x=**, **y=**, **z=**, **t1=**, **t2=**, or **t3=**. It will not work.

Example

Consider the following **block** command, which was used to initialize the part shown in **Figure 208**:

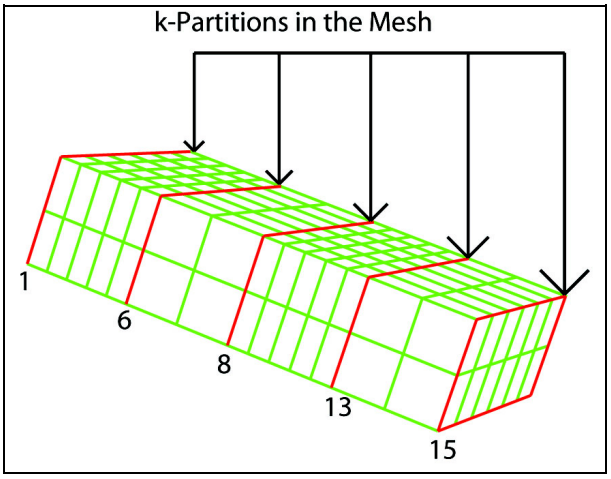


Figure 208 before mseq

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
block
      1 3 5 7;1 3;1 6 8 13 15;
      1 3 5 7;1 3;1 3 5  7  9;
```

There are 4 partitions in the z-direction.

If the following **mseq** command is used:

```
mseq k 2 0 -1 4
```

then the regions in the k-direction will be modified. The first region will be increased by 2 elements. The second region will be unaffected. The third region will be reduced by 1 element and the last region will be increased by 4 elements.

This will have the same effect as the single **block** command:

```
block
      1 3 5 7;1 3;1 8 10 14 20;
      1 3 5 7;1 3;1 3  5  7  9;
```

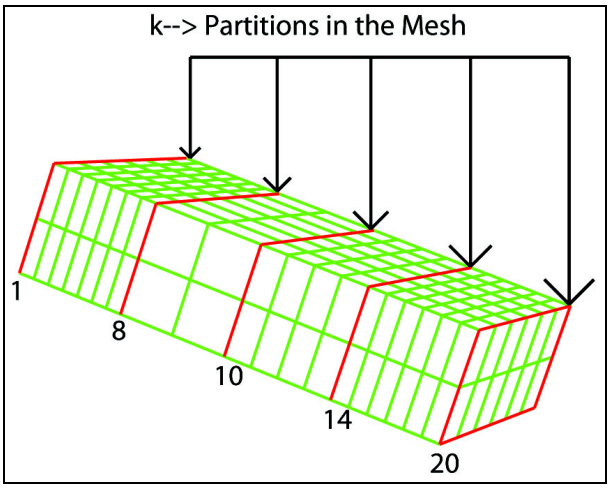


Figure 209 after mseq

orpt set shell element normal orientation

orpt + *x y z* to direct the positive normal direction towards a point
or
orpt - *x y z* to direct the positive normal direction away from a point
or
orpt off to use the default choice of positive normal directions
or
orpt flip to use the inverse of the default choice of positive normal directions

where
x is the first Cartesian coordinate of the orientation point,
y is the second Cartesian coordinate of the orientation point, and
z is the third Cartesian coordinate of the orientation point.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

The **orpt** command must be used prior to any command which depends on the orientation of surface or shell normals. Subsequent use of **orpt** will not influence previously issued commands.

This command determines the positive direction of normals to any shell elements. Some commands treat the two sides of an object differently. For example, pressure is positive when applied to one side of a face and negative when applied to the opposite side.

You can specify that the positive direction be towards a point or away from a point. You can turn off a prior orientation and revert back to the default algorithm. You can also require that the inverse of the default be used..

Some of the commands affected by the **orpt** command are: **pr**, **pri**, **si**, **sii**, **fl**, **fli**, **cv**, **cvi**, **cvt**, **cvti**, **rb**, **rbi**, **re**, **rei**, **sfb**, **sfbi**, **n**, **ndl**, **bulc**, **fset**, **fseti**, **bb**, **trbb** and **ndli**.

Once you issue an **orpt** command, your choice of orientation will apply to all subsequent surfaces, shells, and other such oriented objects. When you are dealing with several different oriented objects, you will probably have to issue more than one **orpt** command.

Your choice of orientation is interpreted in terms of the part's local coordinate system, after any projections. For example, if the part is generated in cylindrical coordinates using the **cylinder** command, then the command

```
orpt + 5 90 1
```

defines an orientation point at radius 5, angle of 90 degrees, and height of 1 (in cylindrical coordinates). If the part had a cylindrical face with radius 1 and with the z-axis forming the axis of symmetry, the normal vectors associated with this surface would point outwards.

For some objects and some choices of the orientation point, the **orpt** command may be ambiguous. A simple example is a spherical surface and a point outside the sphere; the normal direction towards the point is outward for the half of the sphere nearest the point, and inward for the half of the sphere farthest from the point. You should avoid issuing such an ambiguous command. For a surface that is not curved too much, you can avoid ambiguity by choosing another point. A highly curved surface should be broken into several less curved surfaces.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

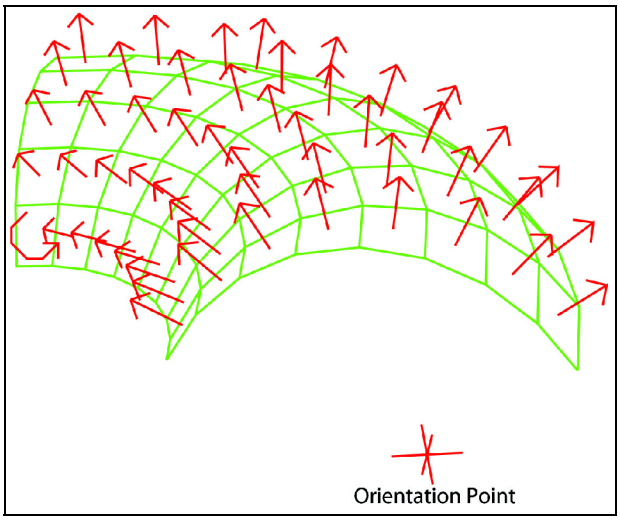


Figure 210 orpt - 9 0 9

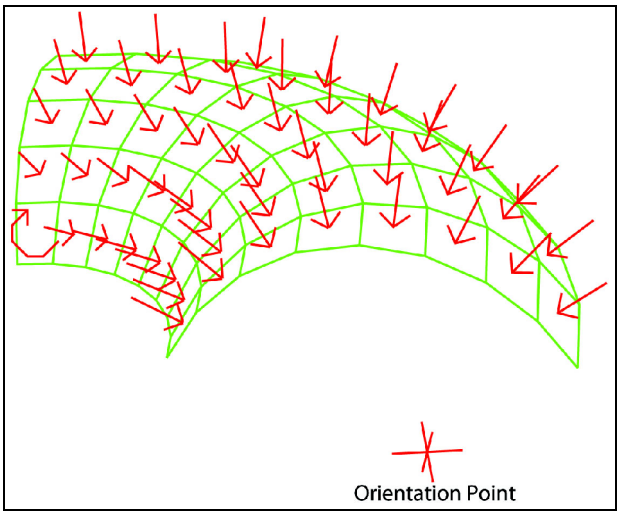


Figure 211 orpt + 9 0 9

The shell element normals (red arrows) in 210 and 211 were created by the use of **`orpt - 9 0 9`** and **`orpt + 9 0 9`** respectively. Here (9 0 9) are the coordinates of the orientation point. Use the **condition** command to display these normal vectors (**condition n**).

update save the mesh's present state as the initial mesh

update *(no arguments)*

Remarks

Each time **update** is issued within the generation of a block part, the present state of the mesh is stored. Any subsequent commands for this part are then applied to the stored mesh. The stored mesh acts as the initial mesh. The temporary variables t1, t2, and t3 are initialized to zero each time this command is issued. This command is almost never needed and interferes with the Command Hierarchy. Its usage is strongly discouraged and should only be used by experts. It was implemented to permit successive projections.

When a new part is initialized, it is as if the **update** command were issued. In this case, the initial mesh is the simple block mesh with the coordinates assigned by the **block** command.
Each time additional geometry or topology commands are issued, followed by either the **update**, **endpart**, or graphics commands, then the mesh is reinitialized to the stored state. Only then are the geometry and topology commands all executed in the proper order. Notice that this means that many useful commands, such as **mseq**, can not be used after issuing an **update**!

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This command can be used after first projecting the initial mesh to a simple surface. Then a second projection can be performed, using the first projection as the initial mesh for the second projection. This one case is the reason that this command was defined. And it is still almost always better to achieve the same effect without utilizing this command.

Update is also a way to combine the projection of the mesh with the algebraic manipulation of the mesh. First, project the mesh to a surface. After issuing an **update** command, you can apply algebraic equations to the result of the projection. See **dom**, **x**, **y**, **z**, **t1**, **t2**, and **t3**.

Any number of updates can be issued. However, commands in the history window will only go back as far as the last update command. No commands before the last update can be deactivated or reactivated.

Example

```
sfi -1 -4;-1 -4;; sd 1
update
sfi -1 -4;-1 -4;; sd 2
```

The four faces of the mesh specified in the **sfi** command are first projected to surface number 1. This mesh is then saved and treated as the initial state of the mesh. Effectively, results of the first projection are used as the initial mesh to be projected onto the second surface.

2. Initial Positioning of Vertices

The commands in this section all assign coordinates to vertices. These commands are automatically executed before all interpolation and projection commands. These commands have one main purpose: to position the vertices of the mesh prior to the projection to surfaces. If no projections are used, these commands serve only one purpose which is to set the boundary conditions for the interpolation. In some cases, these initialization commands are sufficient to produce the desired mesh.

Whatever the order in which commands are issued for a part, they will be sorted according to the Command Hierarchy. This order of execution is:

1. Initialize. There are three types of initialization:
   i) **block** and **cylinder** commands can contain initial coordinates of the vertices.
   ii) Slave side of **bb** and **trbb** initializes and freezes block interface nodes.
   iii) **pb**, **mb**, **pbs**, **q**, **tr**, and **ilin** commands initialize vertices.
2. Apply specified interpolation of edges along 3D curves (**cur**, **curf**, **curs**, **cure**, **edge**, **splint**, **patch**)
3. Project vertices to specified surfaces (**sf**, **ms**, **ssf**, **spp**).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

4. Apply specified edge linear interpolations (**lin**).
5. Apply default edge linear interpolations.
6. Project edges to specified surfaces (**sf**, **ms**, **ssf**, **spp**, **patch**).
7. Apply specified bi-linear interpolations of faces (**lin**).
8. Apply default modified bi-linear interpolation of faces.
9. Project faces to specified surfaces (**sf**, **ms**, **ssf**, **spp**).
10. Perform transfinite interpolation of specified faces (**tf**).
11. Apply equipotential relaxation of specified faces (**relax** and **esm**).
12. Apply Thomas-Middlecoff elliptic solver for specified faces (**tme** and **unifm**).
13. Re-interpolate and project edges and faces affected by 11, 12, and 13 above.
14. Apply specified tri-linear interpolation of solid regions (**lin**).
15. Apply default modified tri-linear interpolation of solid regions.
16. Perform transfinite interpolation for specified solid regions (**tf**).
17. Apply equipotential relaxation for specified solid regions (**relax**).
18. Apply Thomas-Middlecoff elliptic solver for specified solid regions (**tme**).
19. Apply uniform smoothing elliptic solver for specified solid regions (**unifm**).
20. Evaluate expressions (**x=**, **y=**, **z=**, **t1=**, **t2=**, **t3=**).
21. Apply block boundary interface - master side (**bb**).

These vertex placement commands will be executed first. When several of these commands are issued for the same vertex, they are applied to the mesh in the order in which they are issued.

When you specify a region, the values will affect all vertices within the region.

Only the specified coordinate components are assigned values or have an increment added to their values. The unspecified coordinate components keep their previous coordinates.

In a **cylinder** part, the x, y, and z coordinates are interpreted as the radius, angle, and z coordinates respectively in the local coordinate system of the part (see **cycorsy** command).

mb translates vertices

mb *region coordinate_identifier offset*

where

the format for *offset* depends on the following *coordinate_identifier*:

x *x_offset*
y *y_offset*
z *z_offset*
xy *x_offset y_offset*
xz *x_offset z_offset*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

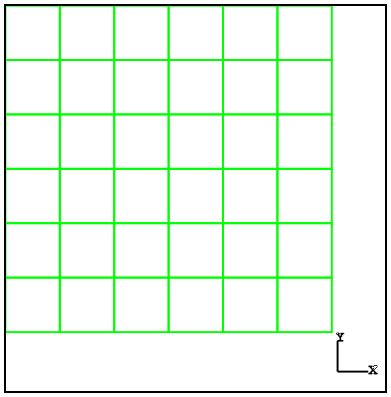
yz *y_offset z_offset*
xyz *x_offset y_offset z_offset*

Remarks

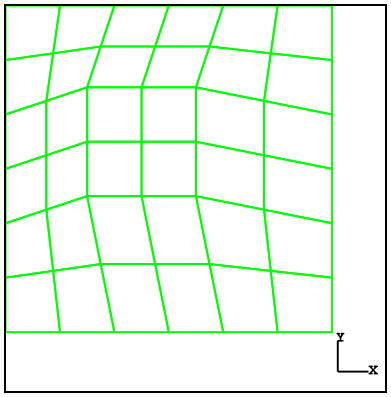
Add the *offset* to the coordinates of every node in the specified region. This command is recorded in both the text window and the tsave (session file) when the mouse is used to move or attach regions (see ***Move Pts.*** or ***Attach***).

Example

```
block 1 3 5 7;
      1 3 5 7;
      -1;
      -3 -1 1 3;
      -3 -1 1 3;
      0;
mb 2 2 1 3 3 1
   xy -.5 .5
```



Before **mb**



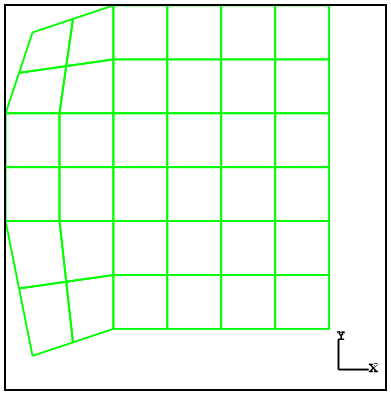
After **mb**

mbi translates vertices

mbi *progression coordinate_identifier offset*
where
the format for *offset* depends on the following *coordinate_identifier*:
x *x_offset*
y *y_offset*
z *z_offset*
xy *x_offset y_offset*
xz *x_offset z_offset*
yz *y_offset z_offset*
xyz *x_offset y_offset z_offset*

Remarks

This is the same as the **mb** command above, only it takes an argument of a progression of reduced indices instead of a single region description. This command is recorded in both the text window and the tsave (session file) when the mouse is used to move or attach regions (see ***Move Pts.*** or ***Attach***).



After **mbi**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
block 1 3 5 7;1 3 5 7;-1;
   -3 -1 1 3;-3 -1 1 3;0;
mbi -1; -1 0 -4; -1; xy .5 -.5
```

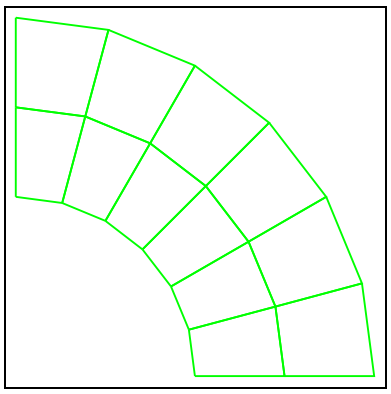
pb assigns coordinates to vertices

pb *region coordinate_identifier coordinates*

where

the format for *coordinates* depends on the following *coordinate_identifier*:

x *x_coordinate*
y *y_coordinate*
z *z_coordinate*
xy *x_coordinate y_coordinate*
xz *x_coordinate z_coordinate*
yz *y_coordinate z_coordinate*
xyz *x_coordinate y_coordinate z_coordinate*



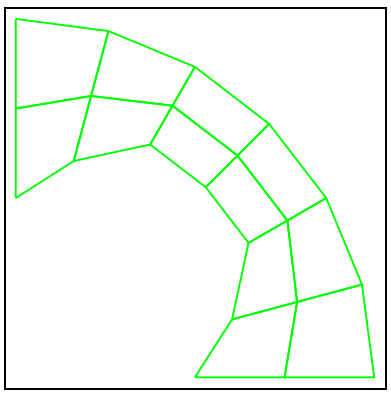
Before **pb**

Remarks

Set the specified coordinates of every node in the region. This command is recorded in both the text window and the tsave (session file) when the mouse is used to move or attach regions (see ***Move Pts.*** or ***Attach***).

There is a special interaction that takes place when the intra-part **bb** command is issued prior to this command being issued. If two regions of the same part are glued together with the **bb** command, then if one side of the interface (master or slave) is moved with this command, the other side is also moved with the same command.

A problem occurs if the automatic association between the master and slave side of this **bb** interface is not the desired association (see the **bb** command), then one of the **bb** commands (usually the slave side) should be deactivated and the corners of the regions initialized so that their proper association can be easily determined automatically. Then re-issue the **bb** command (do not re-activate the previous one).



After **pb**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
cylinder 1 3;1 3 5 7;-1;
  1 2;0 30 60 90;0;
pb 1 2 1 1 3 1 x 1.5
```

pbs assign coordinates to vertices from a labeled point

pbs *region coordinates point_id*

where

coordinates is one of: **x**, **y**, **z**, **xy**, **xz**, **yz**, or **xyz**, and

point_id is a point identifier.

Remarks

Before issuing this command, you need to get a point identifier. To view labeled surface or 3D curve points, click on the appropriate button from the ***Labels*** panel in the environment window. Then choose to ***Pick*** by ***Label***, click on a point's label, and type the **F8** function key to enter the label either into the dialogue box or the text window. Or click on the ***Attach*** button.

By default, the **pbs** command is substituted with the **pb** command before it is written to the tsave (session) file. The default can be changed so that the **pbs** command is written to the tsave (session) file. See the **cooref** command.

There is a special interaction that takes place when the intra-part **bb** command is issued prior to this command being issued. If two regions of the same part are glued together with the **bb** command, then if one side of the interface (master or slave) is moved with this command, the other side is also moved with the same command.

A problem occurs if the automatic association between the master and slave side of this **bb** interface is not the desired association (see the **bb** command), then one of the **bb** commands (usually the slave side) should be deactivated and the corners of the regions initialized so that their proper association can be easily determined automatically. Then re-issue the **bb** command (do not re-activate the previous one).

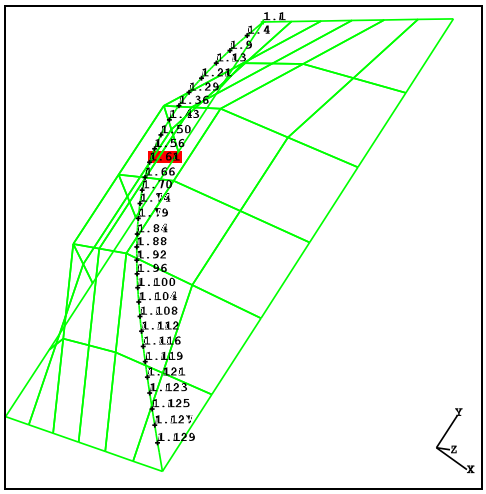
Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
curd 1 csp3 00 0 4 1
 -.54 2.5 2.5 0 1 4 ;;;
block -1;1 3 5 7;1 3 5 7;
 0;1 2 3 4;1 2 3 4;
pbs 1 2 2 1 3 3 x 1.161
```

The tsave will show the following command, substituted for the **pbs** command.

```
pb 1 2 2 1 3 3 x -0.5360755
```



After **pbs**

cooref selects feature in the pbs command

cooref *option*

where *option* can be

symbolic	the **pbs** command is written to the tsave (session) file
absolute	the **pb** command is written to the tsave (session) file

Remarks

The absolute is the default. To facilitate the parametric features, the default method is to save the coordinates, not the label of the point. This is because many surfaces and curves will have a different set of points if anything is changed in the parametric environment. In most cases the original coordinates will still serve its purpose. In those cases where the geometry remains unchanged, or, perhaps the topology of the polygon surface remains unchanged, it is better that the symbol is saved for subsequent runs.

tr transform a region of the mesh

tr *region trans;*

where a *trans* is a transform which is formed, left to right, from the following:

mx *x_offset*
my *y_offset*
mz *z_offset*
v *x_offset y_offset z_offset*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rx *theta*
ry *theta*
rz *theta*
raxis *angle* x_0 y_0 z_0 x_n y_n z_n
rxy
ryz
rzx
tf *origin x-axis y-axis*

where each of the arguments consists of a coordinate type followed by coordinate information:

rt *x y z*	Cartesian coordinates
cy *rho theta z*	cylindrical coordinates
sp *rho theta phi*	spherical coordinates
pt *c.i*	label of a labeled point from a 3D curve
pt *s.i.j*	label of a labeled point from a surface

ftf *1st_origin 1st_x-axis 1st_y-axis 2nd_origin 2nd_x-axis 2nd_y-axis*

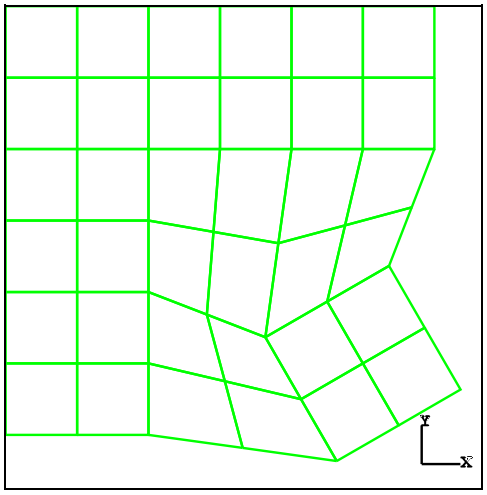
where each of the arguments consists of a coordinate type followed by coordinate information:

rt *x y z*	Cartesian coordinates
cy *rho theta z*	cylindrical coordinates
sp *rho theta phi*	spherical coordinates
pt *c.i*	label of a labeled point from a 3D curve
pt *s.i.j*	label of a labeled point from a surface

inv invert the present transformation
csca *scale_factor*
xsca *scale_factor*
ysca *scale_factor*
zsca *scale_factor*

Remarks

This command transforms a region of the mesh before interpolations, projections, and smoothing functions are performed. All operations are performed in Cartesian coordinates. This command is recorded in both the text window and the tsave (session file) when the mouse is used to move or attach regions (see ***Move Pts.*** or ***Attach***).



After **tr**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
block 1 3 5 7;1 3 5 7;-1;
    -3 -1 1 3;-3 -1 1 3;0;
tr 3 1 1 4 2 1
    v -2 2 0
    rz 30
    v 2 -2 0;
```

tri transform regions of the mesh

tri progression *trans;*

where a *trans* is a transform which is formed, left to right, from the following:

mx *x_offset*
my *y_offset*
mz *z_offset*
v *x_offset y_offset z_offset*
rx *theta*
ry *theta*
rz *theta*
raxis *angle* x_0 y_0 z_0 x_n y_n z_n
rxy
ryz
rzx
tf *origin x-axis y-axis*

where each argument consists of a coordinate type followed by coordinate info.:

rt *x y z*	Cartesian coordinates
cy *rho theta z*	cylindrical coordinates
sp *rho theta phi*	spherical coordinates
pt *c.i*	label of a labeled point from a 3D curve
pt *s.i.j*	label of a labeled point from a surface

ftf *1st_origin 1st_x-axis 1st_y-axis 2nd_origin 2nd_x-axis 2nd_y-axis*

where each argument consists of a coordinate type followed by coordinate info.:

rt *x y z*	Cartesian coordinates
cy *rho theta z*	cylindrical coordinates
sp *rho theta phi*	spherical coordinates
pt *c.i*	label of a labeled point from a 3D curve
pt *s.i.j*	label of a labeled point from a surface

inv invert the present transformation

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

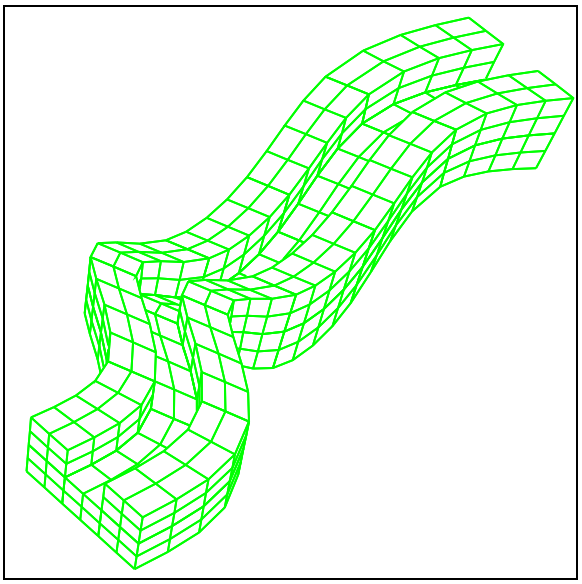
csca *scale_factor*
xsca *scale_factor*
ysca *scale_factor*
zsca *scale_factor*

Remarks

This command is the same as multiple invocations of the **tr** command, described above.

Example

```
block 1 5 9 13 17 21 25;
  1 3 5 7;
  1 3 5;
  0 0 0 0 0 0 0;i
  -3 -1 1 3;
  0 2 4;
dei ; 2 3; 2 3;
tri -2;;;rz 20 mx 5 ;
tri -3;;;rz 20 mx 8 my 4;
tri -4;;;ry 20 rz 20 v 12 4 -4;
tri -5;;;ry 20 rz 20 v 17 4 -4;
tri -6;;;rz 20 mx 22 my 4;
tri -7;;;ry 20 mx 27 my 2;
splint 1 1 1 7 4 3 i 00
```



Curved channel using **tri**

ilin initial interpolation - not a constraint

ilin *region*

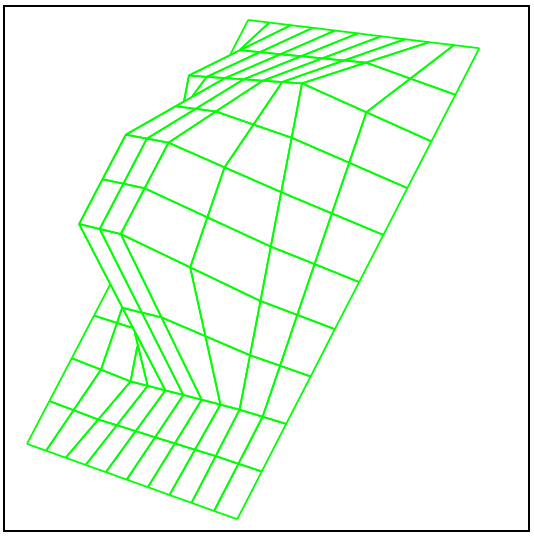
Remarks

This interpolation command can be used to align interior vertices once boundary vertices have been moved to their initial positions. This is a linear interpolation. This command positions intermediate vertices. It is only an initial interpolation. After this command is issued, the interior vertices of the region can be moved again. No constraints are assigned to the interior vertices by this command.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
block -1;
   1 3 5 7 9 11;
   1 3 5 7 9 11;
   0;
   1 3 5 7 9 11;
   1 3 5 7 9 11;
mb 1 5 5 1 5 5 x 2
mb 1 2 5 1 2 5 x 1.5
mb 1 2 2 1 2 2 x -.5
ilini -1; 2 5; -2 0 -5;
ilini -1; -2 0 -5; 2 5;
ilin 1 2 2 1 5 5
pb 1 3 3 1 4 4 x 3
```



Interaction of several initializations

ilini initial interpolation - not a constraint

ilini *progression*

Remarks

This interpolation command can be used to align interior vertices once end vertices have been moved to their initial positions. This is a linear interpolation. This command positions intermediate vertices. It is only an initial interpolation. After this command is issued, the interior vertices of the region can be moved again. No constraints are assigned to the interior vertices by this command.

ma translates vertex before interpolations or projections

ma *vertex coordinate_identifier offset*

where a *vertex* is

i j k reduced indices

where the format for *offset* depends on the following *coordinate_identifier*:

x *x_offset*
y *y_offset*
z *z_offset*
xy *x_offset y_offset*
xz *x_offset z_offset*
yz *y_offset z_offset*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

xyz *x_offset y_offset z_offset*

Remarks

This command works just like the **mb** command, applied to a single vertex. This command has a shorter argument list but everything that this command does can be done with the **mb** command.

Example

In this simple example, a one element shell part is formed by moving one vertex to match the coordinates of another vertex. The vertex was selected using the mouse and the indices were printed using the **F1** key.

```
block 1 2;1 2;-1;1 2;1 2;0;
ma 2 1 1 y 1
```

pa assigns coordinate values to a vertex

pa *vertex coordinate_identifier coordinate*

where a *vertex* is

i j k reduced indices

where the format for the *coordinate* depends on the following *coordinate_identifier*:

x	*x_coordinate*
y	*y_coordinate*
z	*z_coordinate*
xy	*x_coordinate y_coordinate*
xz	*x_coordinate z_coordinate*
yz	*y_coordinate z_coordinate*
xyz	*x_coordinate y_coordinate z_coordinate*

Remarks

This command assigns a vertex coordinate values (moves the vertex). This command is like the **pb** command. This command has a shorter argument list than the **pb** command and everything that this command does can be done with the **pb** command.

Example

In this simple example, a single element part is used to create a wedge element. The vertex was

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

selected using the mouse and the indices were printed using the **F1** key.

```
block 1 2;1 2;1 2;0 2;0 2;0 2;
pa 1 2 2 x 2
pa 1 2 1 x 2
```

q assigns coordinates of one vertex to another

q *1st_vertex 2nd_vertex*
where a *vertex* is
i j k reduced indices

Remarks

This command assigns the coordinates of the second vertex to the first vertex.

Example

This simple example creates a single wedge element by moving two vertices to collapse a face to an edge. The vertices were selected using the mouse and the indices were printed using the **F1** key.

```
block 1 2;1 2;1 2;1 2;1 2;1 2;
q 1 2 2 2 2 2
q 1 2 1 2 2 1
```

3. Initial Positioning of Edges

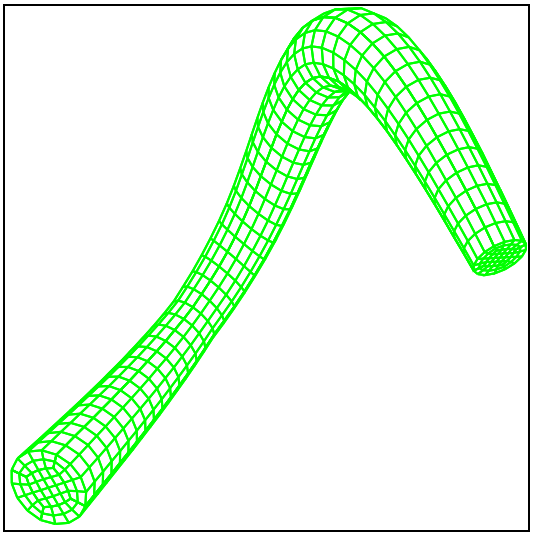
3D curves and surface edges are used to control the shape of an edge of the mesh. This is useful in a number of situations.

In some situations, you may only have 3D curves that define the geometry. If you attach the edges of the mesh to the 3D curves, the faces will be automatically interpolated. There is a good example of this in the discussion of the **edge** command below. Note that, in this example, the face is not projected to the surface and yet the mesh has nearly the proper shape for the surface. You can also use a different interpolation than the default to vary the result. This is particularly useful when using a butterfly topology with surfaces with large variations in curvature. 3D curves can be used to initialize the edges.

```
c Center curve
curd 1 csp3 00 -.18 -.66 .73 .36 .44 .82
                .92 .36 .29 .11 -.15 -.98;;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
c Pipe surface
sd 1 pipe 1 .1 0 .15 .3 .1 .7 .15 1;;
c Interior offset surface to form interior 3D curves
sd 2 pipe 1 .06 0 .09 .3 .06 .7 .09 1;;
c Contour curves extracted from surface2
curd 2 contour 2.1.1 2.0.1;
curd 3 contour 2.1.28 2.0.28;
curd 4 contour 2.1.55 2.0.55;
curd 5 contour 2.1.82 2.0.82;
intyp 2 c Use higher quality interpolation
c Pipe part using butterfly topology
block 1 3 7 9;1 3 7 9;1 51;0 0 0 0;0 0 0 0;0 0;
pb 1 1 1 4 4 1 xyz  -.18 -.66 .73
pb 1 1 2 4 4 2 xyz .11 -.15 -.98
dei 1 2 0 3 4; 1 2 0 3 4;;
c Attach all k-edges to curves
cure 1 2 1 1 2 2 2
cure 2 2 1 2 2 2 2
cure 2 1 1 2 1 2 2
cure 3 1 1 3 1 2 3
cure 3 2 1 3 2 2 3
cure 4 2 1 4 2 2 3
cure 4 3 1 4 3 2 4
cure 3 3 1 3 3 2 4
cure 3 4 1 3 4 2 4
cure 2 4 1 2 4 2 5
cure 2 3 1 2 3 2 5
cure 1 3 1 1 3 2 5
c Project to the pipe surface
sfi -1 -4; -1 -4;;sd 1
c Glue the corners together for smoothing
bb 2 3 1 2 4 2 1;bb 1 3 1 2 3 2 1;
bb 1 2 1 2 2 2 2;bb 2 1 1 2 2 2 2;
bb 3 1 1 3 2 2 3;bb 3 2 1 4 2 2 3;
bb 3 3 1 4 3 2 4;bb 3 3 1 3 4 2 4;
c Smooth the exterior faces
unifm 4 2 1 4 3 2 & 2 4 1 3 4 2 &
      1 2 1 1 3 2 & 2 1 1 3 1 2 30 0 1 ;
unifm 2 1 2 3 4 2 & 1 2 2 2 3 2 & 3 2 2 4 3 2 10 0 1 ;
unifm 1 2 1 4 3 1 & 2 3 1 3 4 1 & 2 1 1 3 2 1 10 0 1 ;
c Smooth the interior
unifm 1 2 1 4 3 2 & 2 1 1 3 2 2 & 2 3 1 3 4 2 40 0 1 ;
```

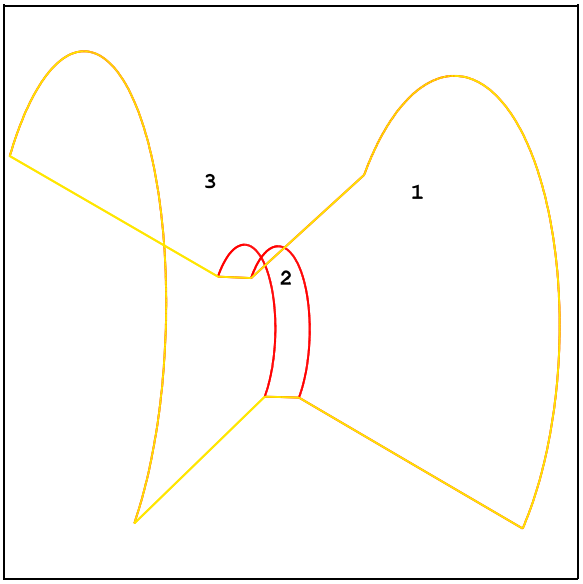


Variable thickness tube

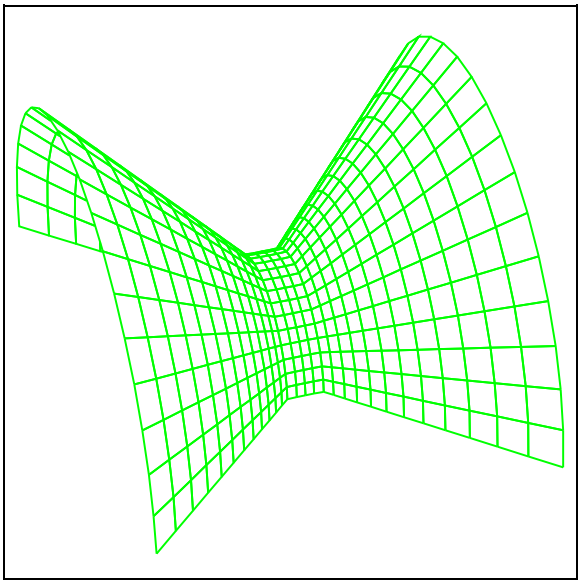
Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

If a surface boundary is convex and you want a face of the mesh to cover the entire surface, than attach the edge of the mesh to the edge(s) of the surface. A variation of this is when you form a composite surface with the **sd** command using the sds option. Then form the composite boundary curve using the **coedge** command. To shape the mesh, attach the boundary edges of the mesh to the composite curve and project the face(s) of the mesh to the composite surface. For example:

```
sd 1 function 0 180 0 1 (.5+v)*cos(u);(.5+v)*sin(u);.1+v;;
sd 2 function 0 180 -.1 .1 .5*cos(u);.5*sin(u);v;;
sd 3 function 0 180 0 1 (.5+v)*cos(u);(.5+v)*sin(u);-.1-v;;
curd 1 se 1.2;se 2.2;se 3.2;se 3.3;
       se 3.4;se 2.4;se 1.4;se 1.3
block 1 21;-1;1 29;-1.5 1.5;0;-1.1 1.1;
curs 1 1 1 1 1 2 1
curs 2 1 1 2 1 2 1
curs 1 1 1 2 1 1 1
curs 1 1 2 2 1 2 1
sd 4 sds 1 2 3;
sfi ;-1;;sd 4
das 1 1 1 2 1 2 k .2 .2
```



3 Surfaces and bounding Curve

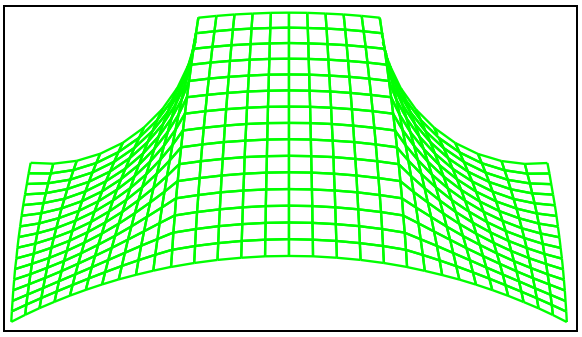

Single block on composite surface

Sometimes, in tight spots, none of the interpolation methods produce the desired effect. If a partition is inserted, using the **insprt** command, and if a 3D curve is carefully formed, the unruly new edge can

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

be shaped with the 3D curve to give the desired effect. This can be combined with smoothing and nodal distributions. This is a common technique used in a final mesh quality improvement step. Foe example:

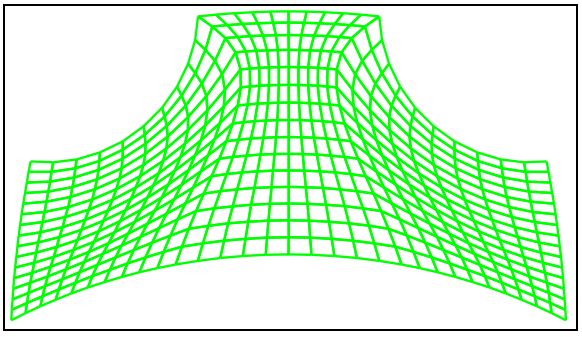
```
sd 1 sp 0 0 0 5
sd 2 cy -2 2 0 0 0 1 1.25
sd 3 cy 2 2 0 0 0 1 1.25
sd 4 cy 0 -5 0 0 0 1 5
sd 5 cy 0 -5 0 0 0 1 7
block 1 11 21 31;1 16;-1;
      -3 -1 1 3 0 3 5
pb 4 2 1 4 2 1 xy 2.5 0.5
pb 1 2 1 1 2 1 xy -2.5 0.5
sfi ;; -1; sd 1
sfi 2 3; -2; -1; sd 5
sfi 1 2; -2; -1; sd 2
sfi 3 4; -2; -1; sd 3
sfi ; -1; -1; sd 4
```



Crude interpolation

Two 3D curves are carefully constructed to form the interior shape that improves the quality.

```
curd 1 csp3 00
-.750  1.959 4.538
-.474  1.727 4.668
-.788   .352 4.923
-.962  -.093 4.905;;
curd 2 csp3 00
.750  1.959 4.538
.474  1.727 4.668
.788   .352 4.925
.962  -.093 4.905;;
curs 2 1 1 2 2 1 1
curs 3 1 1 3 2 1 2
```



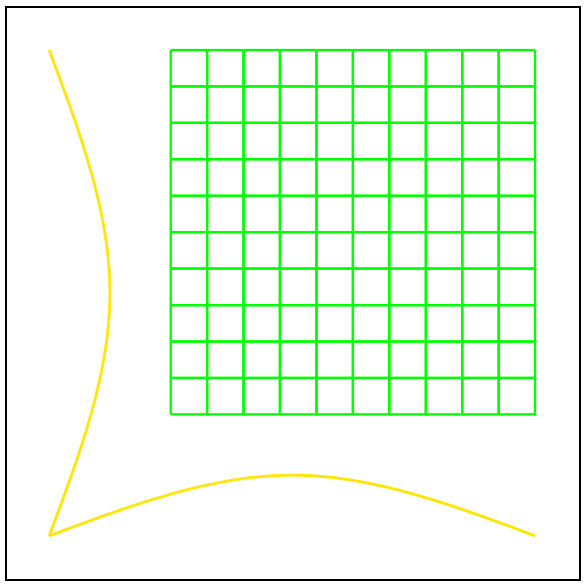
Improved quality using 3D curves

Attaching a mesh edge to a 3D curve or a surface edge is considered an initialization, not a constraint (except for the **curf** command where the edge is frozen to the curve). There are good reasons for this. It would be difficult and contrived to intersect two 3D curves. In almost all non-trivial cases, 3D curves do not intersect. The intersection of a 3D curve and a surface has similar complications, since a 3D curve almost never lies on a surface. In particular, when two edges with a common vertex are attached to different 3D curves, be sure to initialize the common vertex to the intersection of the curves.

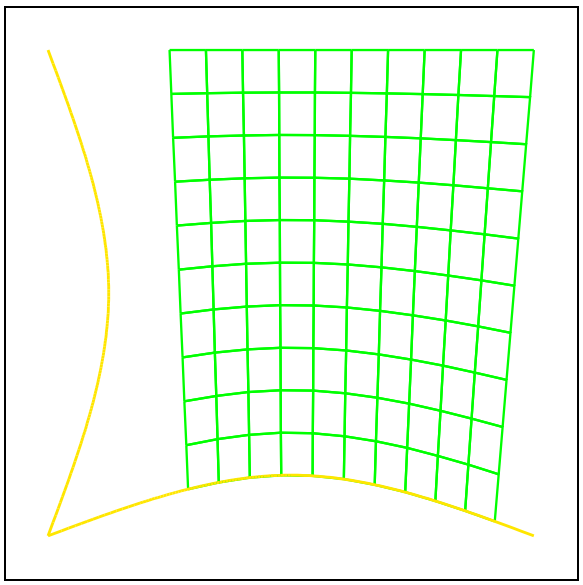
Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
curd 1 csp3 00 -1 1 0 -.75 0 0 -1 -1 0;;
curd 2 csp3 00 1 -1 0 0 -.75 0 -1 -1 0;;
block 1 11;1 11;-1;-.5 1;-.5 1;0;
curs 1 1 1 2 1 1 2
curs 1 1 1 1 2 1 1

pb 1 1 1 1 1 1 xy -1 -1
```

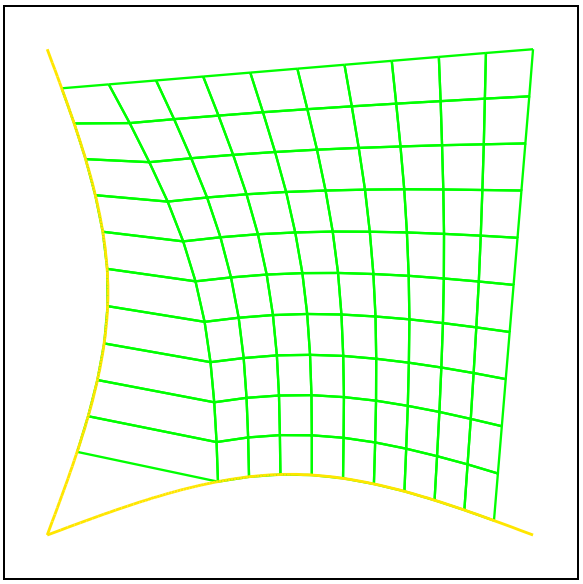


Initial mesh

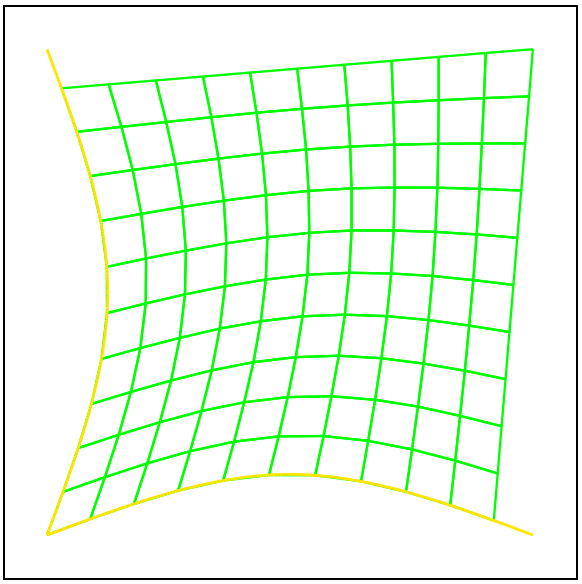


Attached to 1 curve

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved



Attached to 2 curves

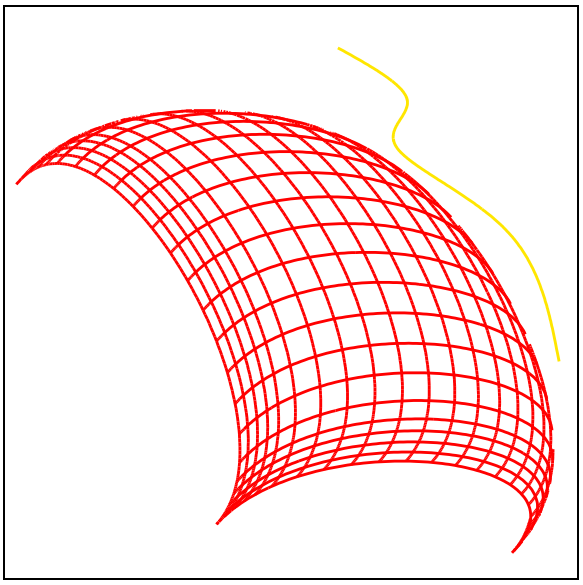


Vertex initialized to intersection

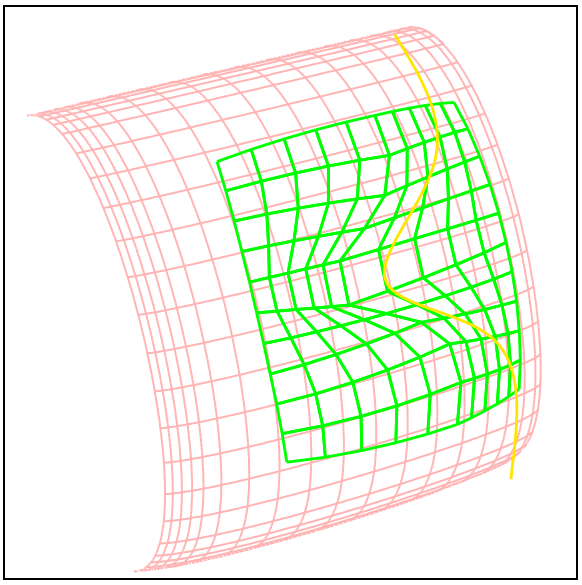
When an edge of the mesh is attached to a 3D curve and projected to a surface, the nodes of the edge will retain the shape of the 3D curve projected to that surface. The 3D curve does not need to be on the surface or even close to the surface. For example:

```
sd 1 csps 2 2 1111 0 0 1 0 0 1 0 0 -1 0 0 -1 0 0 1 0 0 1
                   0 0 -1 0 0 -1 0 0 0 1 0 0 0 1 0 1 1 0 ; ;
curd 1 csp3 00 .569 .992 .568 .534 .726 .656
  .329 .515 .669 .581 .330 .651 .611 .257 .564;;
block 1 6 11;1 11;-1;.1 .5 .9;.1 .9;.6;
curs 2 1 1 2 2 1 1
sfi ;; -1; sd 1
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved



3D curve off of a surface

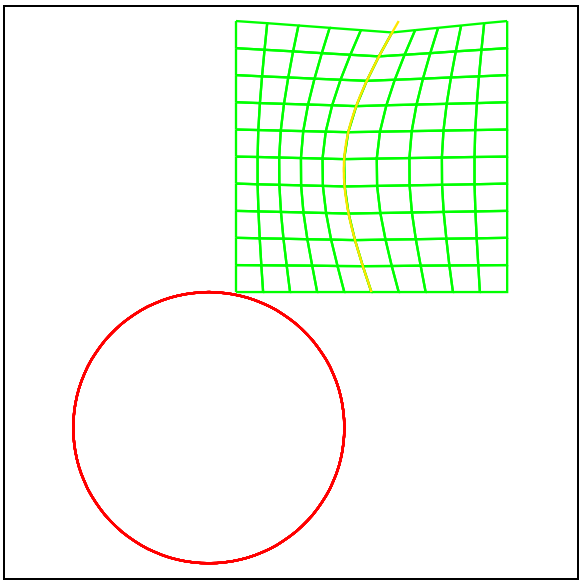


Attach and project

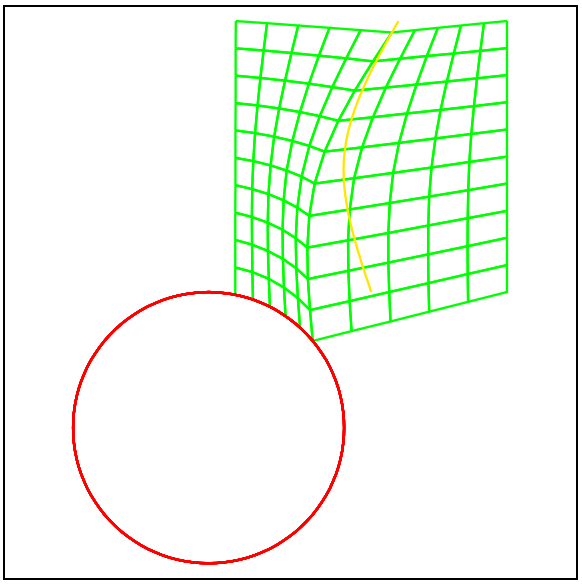
When an edge of the mesh is projected to one surface, a plane is constructed that is approximately perpendicular to the surface. This is done by averaging the normals of the surface at the two end points of the edge. Then the edge is placed on the intersection of this plane and the surface. However, when an edge is attached to a 3D curve and projected to one surface, the edge is not forced to be on this additional planer surface.

When an edge is attached to a 3D curve with the end of the edge projected to a surface, then the edge nodes will be smoothly lifted off of the 3D curve so that the end of the edge can lie on the surface. For example:

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved



Edge attached to curve



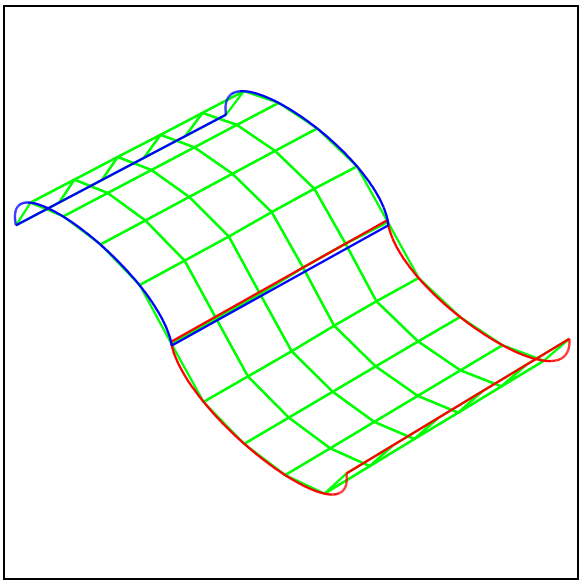
Edge end also projected

```
block 1 6 11;1 11;-1;1 6 11;1 11;1;
sd 1 cy 0 -4 0 0 0 1 5
curd 1 csp3 00 6 1 1 5 6 1 7 11 1;;
curs 2 1 1 2 2 1 1
sfi 1 2;-1;;sd 1
```

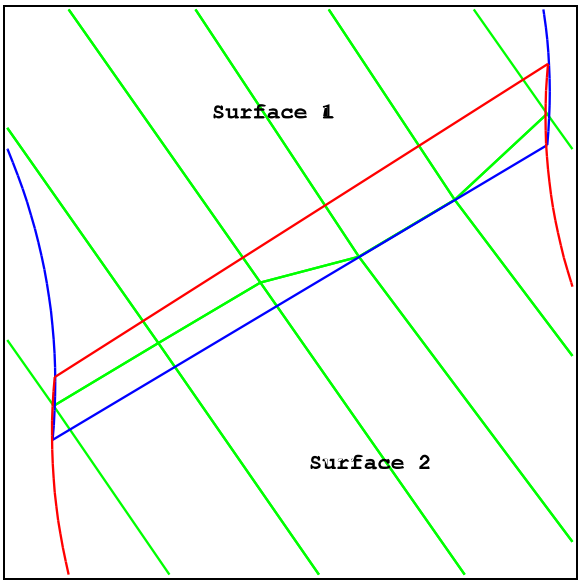
In most cases, it is not very useful to attach an edge of the mesh and project it to the intersection of two surfaces. The exception is when the two surfaces are nearly tangent. In this case, the intersection may take a long time and it may fail. This is because the super convergent Newton method for intersecting two surfaces cannot be employed in this case since it would cause a division by zero. If the edge is attached to a 3D curve that is very close to the intersection of these two surfaces, then the method for intersecting nearly tangent surfaces will converge in a reasonable period of time. In severe cases, use the **curf** command so that the edge is forced to remain on the 3D curve and the intersection of the two surfaces is skipped. For example:

```
sd 1 csps 2 2 1100 0 0 1 0 0 1 0 0 -1 0 0 -1
          0 0 0 1 0 0 0 1 0 1 1 0;
sd 2 csps 2 2 1100 0 0 -1 0 0 -1 0 0 1 0 0 1
          .999 0 .0166 2 0 0 .998 1 .0234 2 1 0;
block 1 6 11;1 6;-1;0 .999 2 0 1 .009
sfi 1 2;; -1; sd 1
sfi 2 3;; -1; sd 2
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved



Projection to two surfaces



Wandering edge along intersection

This problem is fixed when the edge in question is attached to a curve using the following commands:

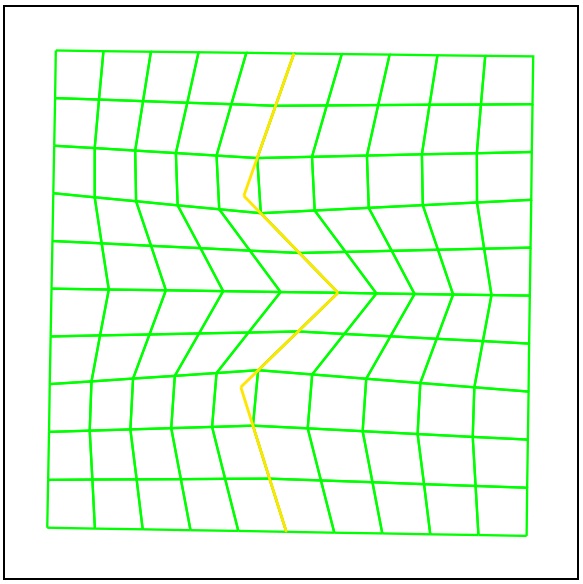
```
curd 1 lp3 1 0 0 1 1 0;;
curs 2 1 1 2 2 1 1
```

The best way to deal with tangent surfaces is to use the composite surface feature (sds) of the **sd** command. Combine the surfaces and project the edge to the composite surface. To be sure that the edge follows the (approximate) intersection of the two surfaces, construct a 3D curve and attach the edge to this curve.

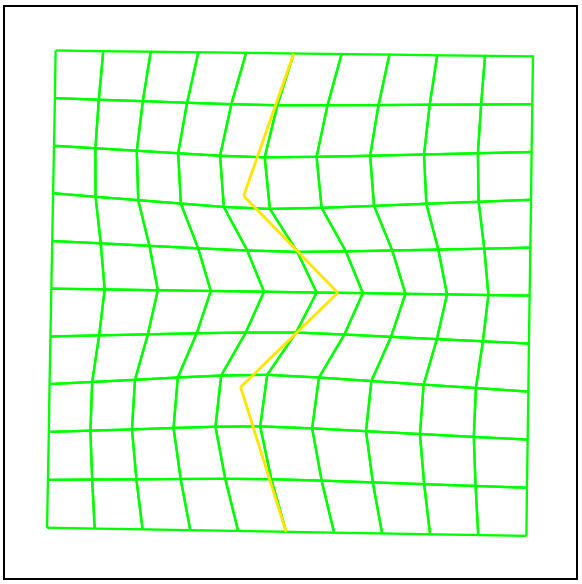
When an interior edge is attached to a 3D curve and is within a region to be smoothed with the **relax**, **unifm**, **esm**, or **tme** commands, the edge nodes are also smoothed and may move off of the 3D curve. This gives you flexibility in creating special effects. For example:

```
block 1 6 11;1 11;-1;0 1 2;0 2;0;
curd 1 lp3 1 2 0 .8 1.4 0 1.2 1 0 .8 .6 0 1 0 0;;
curs 2 1 1 2 2 1 1
relax 1 1 1 3 2 1 4 0 .25
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved



Attach without smoothing



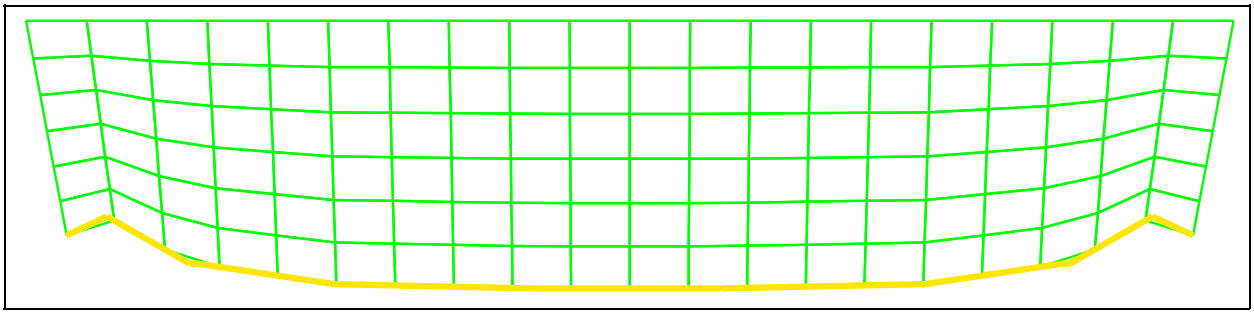
Attach with smoothing

When a 3D curve or surface edge has extreme curvature or is not smooth, it may be impossible for a sequence of nodes to be distributed along that curve equally spaced or by any other nodal distribution you might select. The best way to avoid this is to break the edge into smaller regions so that an intermediate vertex can be placed precisely at the point where there is large curvature or where the curve is not smooth. The following is an example of a curve that does not allow equal spacing of nodes:

```
curd 1 lp3 6.51 -1.22 .74 6.53 -1.18 .69 6.55 -1.24 .58
           6.55 -1.24 .57 6.57 -1.26 .39 6.60 -1.25 .12
           6.60 -1.25 -.13 6.57 -1.26 -.39 6.55 -1.24 -.57
           6.55 -1.24 -.58 6.53 -1.18 -.69 6.51 -1.22 -.74 ;;;
block 1 4;-1;1 11;6 6.5;-1.2;-.75 .75;
curs 2 1 1 2 1 2 1
pb 2 1 1 2 1 1 xyz 6.51 -1.22 -.74
pb 2 1 2 2 1 2 xyz 6.51 -1.22  .74
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

cur distribute edge nodes along a 3D curve



Too much curvature for equally spaced nodes

cur *region curve*

where

curve is the number of a 3D curve

Remarks

An edge of the mesh can be placed onto a 3D curve before any faces are interpolated or projected to surfaces. The placement of an edge onto a 3D curve is done after all other initializations and has an effect similar to initialization.

The end vertices are moved to the closest points on the 3D curve. The remainder of the nodes within the interior of the edge are then interpolated along the curve between the two end vertices. The distribution of the nodes can be further controlled using the **res**, **drs**, **as**, **das**, or **nds** commands.

It is possible to define a closed 3D curve. If this is done, then there are two possible ways to interpolate a sequence of edge nodes between the two end vertices. The shortest arc length path is chosen between the two end vertices.

Care is needed in distributing edge nodes along a 3D curve which has corners or sharp bends. It may be impossible for the iterative method to position the nodes along the curve such that the distances between the nodes satisfy the spacing rules of the **res**, **drs**, **as, das,** and **nds** commands. If this is the case, then a warning message will be issued saying that the nodes may be distributed by arc length along the curve, instead of by chord length between nodes. The best solution to this problem is to add an intermediate partition in the block mesh and place it at the corner or sharp bend of the curve.

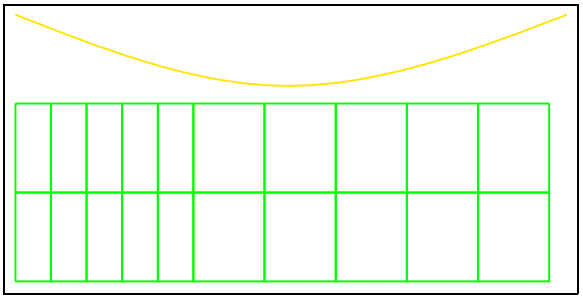
The positioning of an edge along a 3D curve is an initialization of the edge nodes. These same edge nodes can then be projected to one or more surfaces. The projection of this edge to a single surface

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

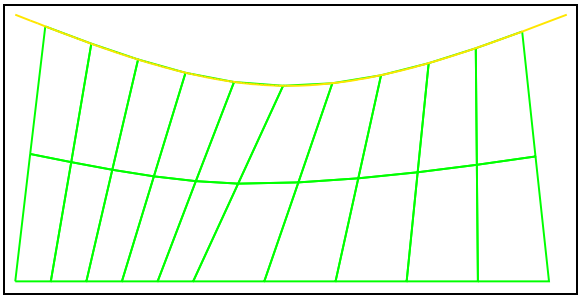
will be done in a special way to preserve the shape of the 3D curve as much as is possible. To appreciate this feature, one needs to be familiar with the way an edge is normally projected onto a surface with moderate curvature. First the end nodes are projected to the surface. Then a plane is constructed passing through the two end nodes and approximately orthogonal to the surface. The edge nodes are then placed along the intersection of the surface and the plane to satisfy the appropriate relative spacing rule. When an edge is initialized along a 3D curve, the intersecting plane is not used. The edge nodes are simply projected to the surface and carefully adjusted to satisfy the appropriate relative spacing rule.

Example

```
block 1 6 11;1 3;-1;.5 1 2 0 .5 0
curd 1 csp3 00 .5 .75 0 1.25 .55 0 2.05 .75 0 ;;
cur 1 2 1 3 2 1 1
```



Part & Curve before attachment



Cur attachment

curf distribute and freeze nodes along a 3D curve

curf *region curve*

where

curve is the number of a 3D curve.

Remarks

This command behaves as the **cur** command does, except that the positions of the edge's nodes are frozen. Projections, interpolations, and relaxations will not effect those nodes that are placed on curves using this command.

cure distribute nodes along an entire 3D curve

cure *region curve*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

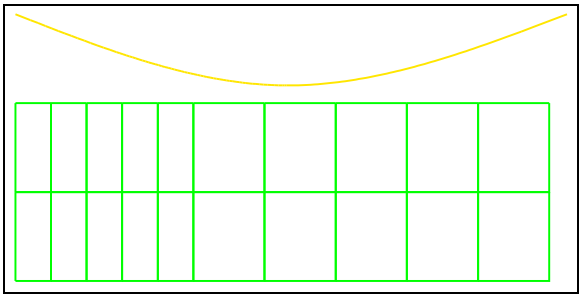
where
curve is the number of a 3D curve.

Remarks

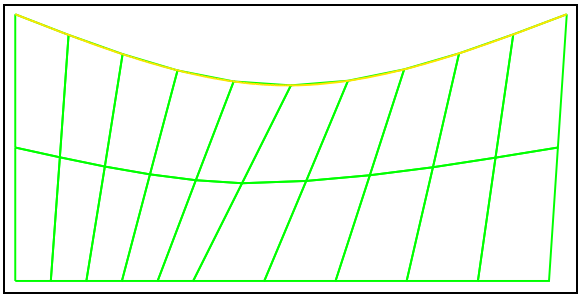
cure performs two functions in one command. First, it places the first and last vertices of the edge at the endpoints of the specified 3D curve. Then it distributes the remaining nodes of the edge along the 3D curve, just like the **cur** command, with the exception that a closed curve is not a special case. The edge of the mesh will cover the entire 3D curve.

Example

```
block 1 6 11;1 3;-1;.5 1 2 0 .5 0
curd 1 csp3 00 .5 .75 0 1.25 .55 0 2.05 .75 0 ;;;
cure 1 2 1 3 2 1 1
```



Part & Curve before attachment



Cure attachment

curs independently distribute edge nodes along a 3D curve

curs *region curve*
where
curve is the number of a 3D curve.

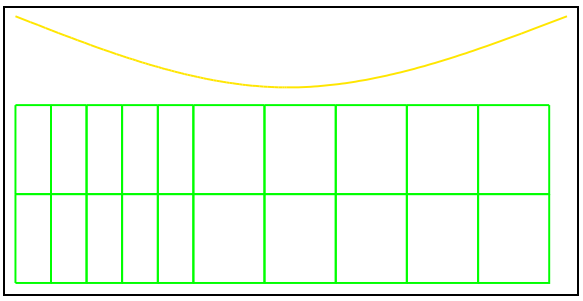
Remarks

Curs has the same effect as issuing the **cur** command for each simple region along an edge of the mesh. The initial position of the vertices along the edge will determine their position along the 3D curve. Each of these nodes will be independently moved to the closest point on the 3D curve. Then the nodes between the vertices will be evenly distributed along the curve.

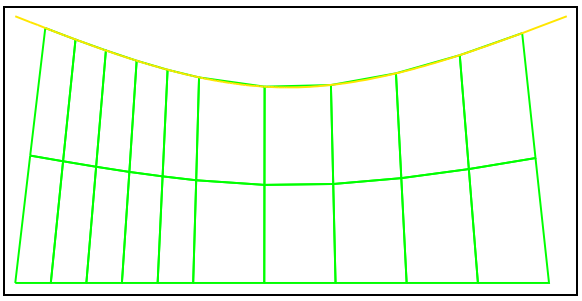
Example

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
block 1 6 11;1 3;-1;.5 1 2 0 .5 0
curd 1 csp3 00 .5 .75 0 1.25 .55 0 2.05 .75 0 ;;;
curs 1 2 1 3 2 1 1
```



Part & Curve before attachment



Curs attachment

edge distribute nodes along an edge of a surface

edge *region edge*

where

edge is the label of a surface edge.

Remarks

Region must be an edge of the mesh and *edge* must be a surface edge identifier, **s.e**. The number **s** is the surface number and the number **e** is the edge number of that surface. To view the edge identifiers of the surfaces in the picture, issue the **labels sdedge** command (or click on the ***Labels*** and ***Surf Edge*** buttons in the Environment Window). You may wish to remove all of the interior lines used to display the surfaces. This is done with the **sdint off** command. The **edge** command works like the **cur** command on a 3D curve. This is a disadvantage in many situations, because there may be many contiguous edges of the mesh that need to be attached to one surface edge. If one edge command is issued for the lot, then all of the intermediate vertices of this sequence of simple mesh edges will loose their independence. If this is not desired, then an edge command is needed for each independent simple edge of the mesh. Sometimes it is better to create a 3D curve from this edge of the surface so that the **curs** command can be used instead. Also see the **cur** command. The easiest way to issue the edge command is by using the ***Attach*** button in the environment window. If an **insprt** command is issued which creates a new partition splitting the edge that is attached to a surface edge, internally, this will be treated as two edge commands. In other words, the new intermediate vertex as a result of the **insprt** command will be independent.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
sd 1 function 0 90 -45 45
 cos(u)*cos(v); sin(u)*cos(v);
      sin(v);
ry -45;

block 1 16;1 11;-1;
       -.5 1; 0 1; 0;

pb 2 2 1 2 2 1 x .5
pb 1 2 1 1 2 1 z .75
pb 1 1 1 1 1 1 xz -.1 .75
```

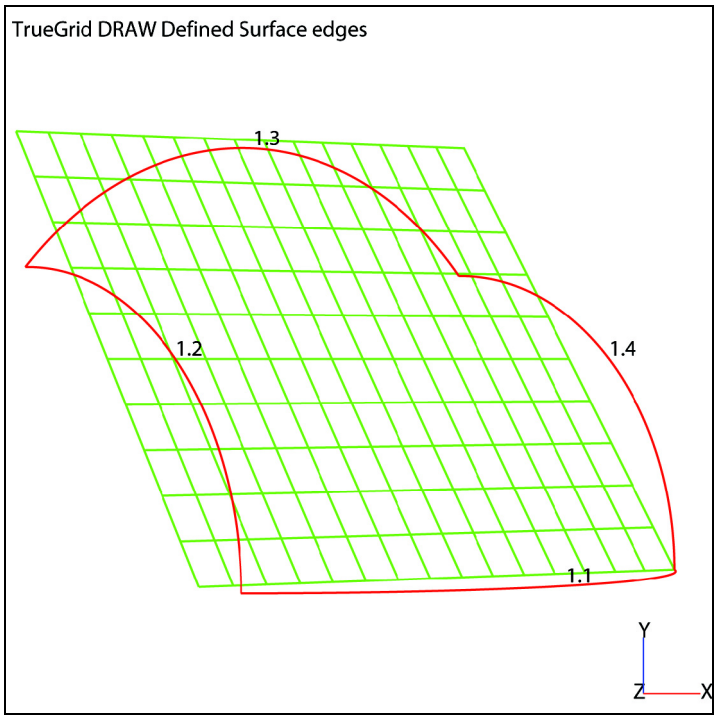


Figure 245 Initial Mesh

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
edge 1 1 1 2 1 1 1.1
```

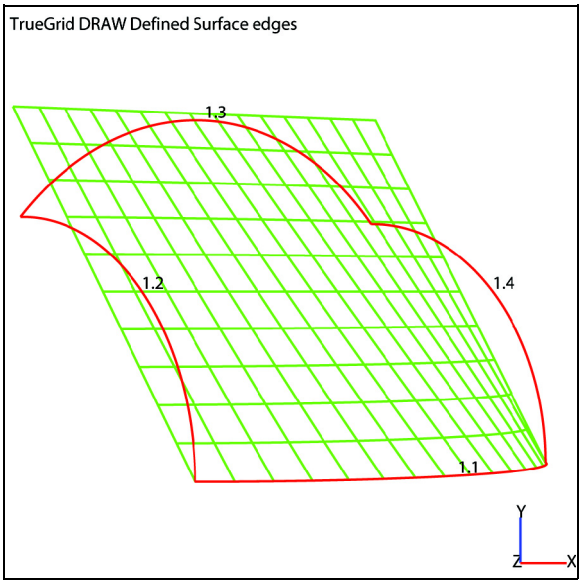


Figure 246 Edge 1 of Surface 1

```
edge 2 1 1 2 2 1 1.4
```

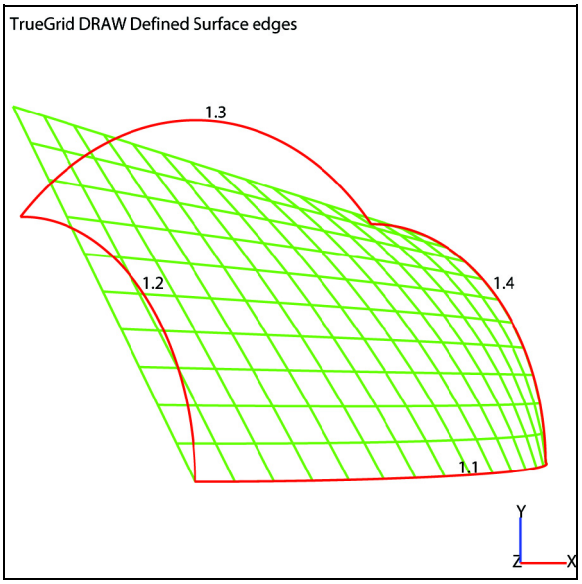


Figure 247 Edge 4 of Surface 1

```
edge 1 1 1 1 2 1 1.2
```

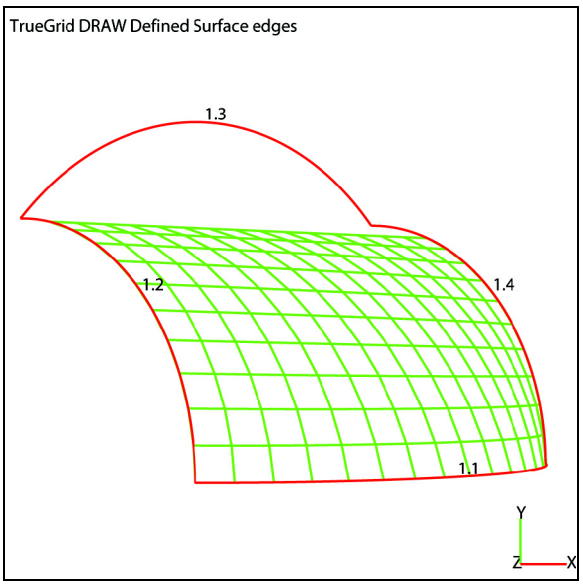


Figure 248 Edge 2 of Surface 1

```
edge 1 2 1 2 2 1 1.3
```

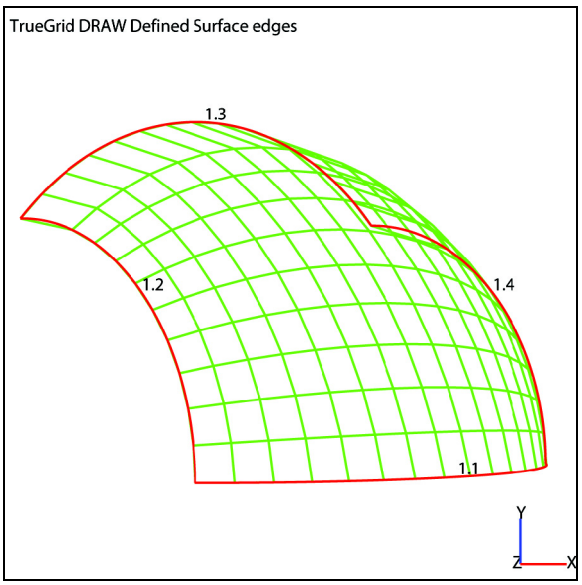


Figure 249 Edge 3 of Surface 1

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

4. Interpolation

The commands in this section distribute interior nodes by interpolation based on the location of the boundary nodes. Interior nodes are all of the nodes between the boundaries of the select region. There are some exceptions.

1. The **relax** command can smooth a region with holes in it where the nodes along the edge of the hole are treated as boundary nodes.

2. The intra-part block boundary (**bb** command) can glue two edges or faces together so that they will be considered, by some of the smoothing commands, as interior nodes.

3. The **unifm** and **unifmi** commands can have a Neumann boundary condition (**neu** and **nuei** commands) which allows the nodes on the boundary to be smoothed along with the interior to produce near orthogonality near the boundaries. The nodes will remain on any surfaces specified by the projection commands. All of the iterative methods (**relax**, **esm**, **unifm**, and **tme**) are solving elliptic differential equations to produce near orthogonality. A node at the boundary is (by default) frozen to its initial position before smoothing. This is known as the Dirichlet boundary condition for differential equations. In the case of the uniform smoothing, you can select some of the boundary nodes to be smoothed by allowing them to move along the surface(s) of projection until they form interior mesh lines that are (nearly) orthogonal to the boundary surface. This is known as the Neumann boundary condition for differential equations. An orthogonal mesh is ideal and is almost never realized except in the most trivial problems. Take this into consideration when interpreting the results of any of the elliptic smoothing methods.

Whatever the order in which you give commands for a part, they will be sorted according to the Command Hierarchy. If several similar commands are issued, they will be executed in the order they were issued.

All nodal interpolations are done in the coordinate system of the part. For a **cylinder** part, the x, y, and z coordinates are interpreted as r, θ, and z coordinates respectively.

Many of these commands use the coordinate positions on the boundary nodes to interpolate the interior nodes. This is done for 1D, 2D, and 3D regions of the mesh.

1D: An edge of the mesh is considered a 1D region. Its boundaries are the two end vertices. The **lin** and **lini** commands are the only commands in this section that can be applied to an edge. Since this is the default interpolation automatically used between adjacent vertices, one would only use this command if the edge spanned multiple regions. The interior nodes are all of the nodes between the two end vertices, including any intermediate vertices.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

2D: A face of the mesh is a 2D region. Its boundary nodes are the edge nodes around the perimeter of the face. None of the perimeter nodes are modified. Only the interior nodes are interpolated. The position of the interior nodes are a function of the position of the boundary nodes.

3D: A volume is an example of a 3D region of the mesh. The boundary nodes are those that form the faces surrounding the volume. None of these boundary nodes are modified. Only the interior nodes are interpolated. The position of the interior nodes are a function of the position of the boundary nodes.

It is possible to select multiple 2D regions in the **relax** , **unifm**, and **esm** commands. The **unifm** command does something similar for volume 3D regions, smoothing across boundaries of disconnected blocks.

esm 2D elliptic smoothing

esm *region {& region} iterations min_change weight α β*

where

iterations	is the maximum number of iterations to use,
min_change	is an absolute error tolerance (there will be no more iterations if, in the last iteration, no coordinate was moved by more than *min_change* in any zone)
weight	is an interpolation weight factor (the value 1.0 usually works)
α	coefficient controlling mesh density near singularities
β	exponential decay controlling mesh density near singularities

Remarks

This command is restricted to faces. This smoothing feature gives you control of the weights used in the equations being solved. This is done by choosing the density and decay factors. It is best to experiment with small variations in these parameters, starting with values close to α=.2 and β=6. This feature is useful when smoothing a section of the mesh where 3 or five blocks meet at a vertex. In other methods, such as **relax**, the section of the mesh near an interior vertex formed by three blocks behave like a concave boundary with the mesh lines attracted to this triple vertex. In contrast, when five blocks meet at a vertex and are smoothed with the **relax** command, the common vertex acts like a convex boundary, repelling mesh lines. The **esm** command, along with the **esmp** command, was designed to counter this effect.

When a face of the mesh is specified, then all interior face nodes are relaxed. If a node is on the boundary it will not be smoothed. Smoothed nodes will be constrained to the surfaces they are projected onto.

The weight factor is used to interpolate between the old nodal coordinates and the new within each

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

iteration of the smoothing. If it is set to 1.0, then the new value is used. If it is set to a smaller number, then a point is interpolated between the new and old coordinates of a node. The interpolation parameter makes it possible to slow or speed up the convergence to the method. In most cases, 1.0 will be a satisfactory value.

Multiple faces can be specified using the ***&*** between region specifications. For example, the three faces of a corner can be specified: an i-face, a j-face, and a k-face. All of the nodes including the three interior edges and the corner node will be smoothed. Disjoint faces can be smoothed together. If the edge of one face is glued to the edge of another face using the intra-part **bb** command, then the coincident nodes along the glued edges edge will also be smoothed. If three, four, or five faces are glued together or have common edges and share a common or glued vertex in the center, that center vertex will be smoothed as well.

The **esmp** command can be used to add additional force to the mesh lines.

If an interior face node is projected to several surfaces, it will remain on the intersection of the surfaces. For example, if a node is required to be along the curve of intersection of two surfaces, it will be smoothed while constrained along that curve. Since boundary nodes are not moved, the nodal distributions along these edges will be preserved. Zoning due to the **res**, **drs**, **as**, **das**, or **nds** commands for interior edges will not be preserved.

Examples

In the following example, several methods are used to interpolate a single block part with all 6 shell faces projected to a sphere. The 8 vertices and 12 edges are treated as interior to the interpolation (except the default interpolation). In particular, notice the subtle differences at the vertices. All examples start with the following:

```
block -1 -31;-1 -31;-1 -31;
      -1 1 -1 1 -1 1
sd 1 sp 0 0 0 1
sfi -1 -2; -1 -2; -1 -2;sd 1
```

center element edge length = 0.041028529

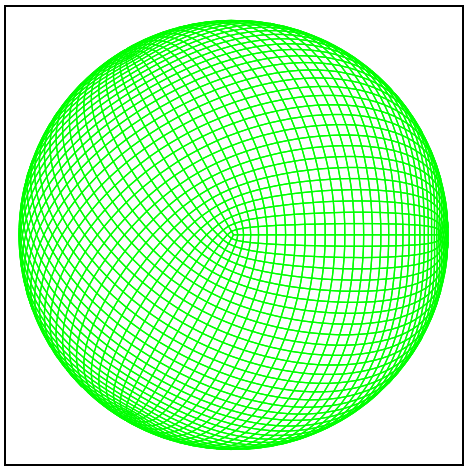


Figure 250 No smoothing

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
relax 1 1 1 1 2 2 & 2 1 1 2 2 2 &
      1 1 1 2 1 2 & 1 2 1 2 2 2 &
      1 1 1 2 2 1 & 1 1 2 2 2 2
      200 .0001 1
```

Every node is relaxed. Notice that the mesh lines hug the corner nodes (the center node). Relax behaves as though each vertex (the result of three blocks meeting at one vertex) where a concave interior boundary.

center element edge length = 0.018319121

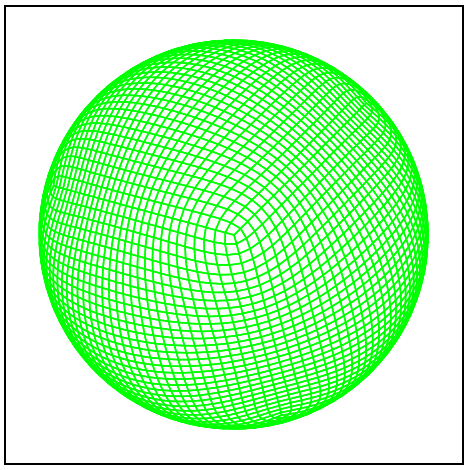


Figure 251 Relax smoothing

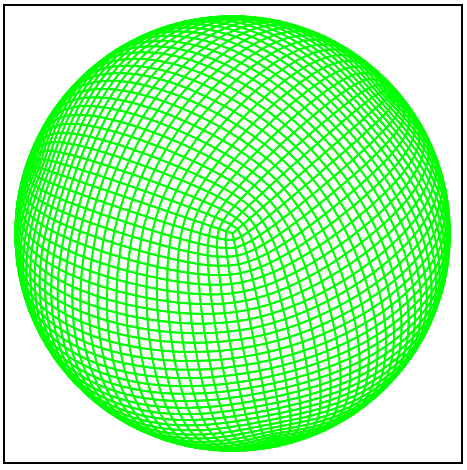


Figure 252 Uniform smoothing

```
unifm 1 1 1 1 2 2 & 2 1 1 2 2 2 &
      1 1 1 2 1 2 & 1 2 1 2 2 2 &
      1 1 1 2 2 1 & 1 1 2 2 2 2
      200 .0001 1
```

Uniform smoothing is better than relax at these vertices.

center element edge length = 0.029181886

```
esm 1 1 1 1 2 2
& 2 1 1 2 2 2 &
    1 1 1 2 1 2
& 1 2 1 2 2 2 &
    1 1 1 2 2 1 & 1 1 2 2 2 2
    200 .0001 1 .2 6
```

When the optimal values for the two control parameters are chosen, the elliptic smoothing can produce the ideal mesh near these triple points in the mesh.

center element edge length = 0.044212352

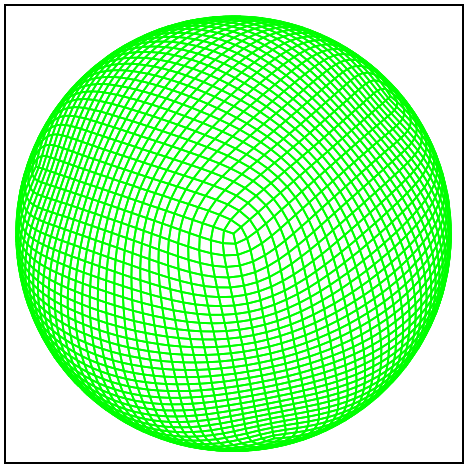


Figure 253 Elliptic smoothing

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

esmp Add source terms for elliptic smoothing

esmp r*egion flag type parameter(s)*

where *flag* can be

0	first node as the source of attraction
1	last node as the source of attraction

where *type* and *parameter(s)* can be

1 *amplitude*	linear function amplitude*(1-ρ)
2 *amplitude*	cubic function amplitude*(2*ρ**3-3*ρ**2+1)
3 *amplitude*	cosine function amplitude*(cosine(ρ*π)+1)
4 *amplitude decay*	exponential function amplitude*exp(-decay*ρ)

where ρ is the relative distance from the point source

Remarks

Any edge in the region of elliptic smoothing (**esm** command) can be assigned sources. A smoothly interpolated source will be superimposed on the source functions (the right hand side) of the elliptic P.D.E.s being solved.

Examples

```
sd 1 sp 0 0 0 4
block 1 11 21;1 11 21;-1;-2 0 2 -2 0 2
4
sfi ;; -1; sd 1
esm 1 1 1 3 3 1 100 .0001 1 .2 6
esmp 2 1 1 2 2 1 1 3 -1
esmp 2 2 1 2 3 1 0 3 -1
esmp 1 2 1 2 2 1 1 3 -1
esmp 2 2 1 3 2 1 0 3 -1
endpart
```

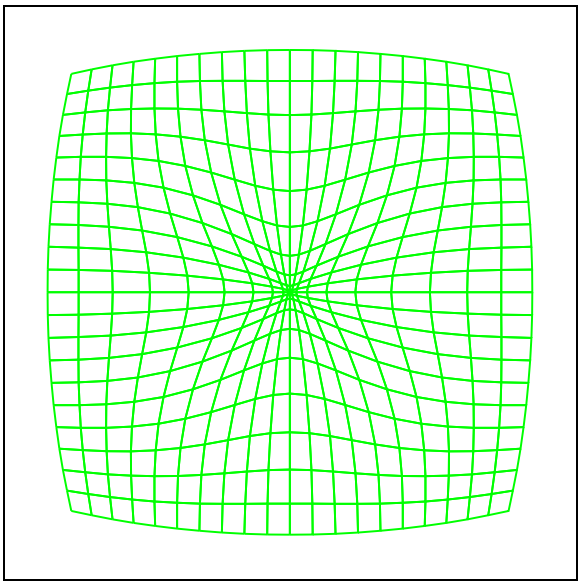


Figure 254 esmp applied to 4 edges

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

hyr Interpolate multiple regions as one region

hyr *region*

Remarks

Most people find that this command is not very useful. It imposes too many constraints that later cannot be switched off without disabling the all of them. This command is like a macro converted it into a sequence of other commands. What the other commands are depends on the type of region. For a solid 3D region, this command causes twelve **res** commands to require equal spacing of nodes along each of the twelve edges. Then it causes six **lin** commands to require bi-linear interpolation of the nodes in each of the six faces. Finally it causes a **lin** command for tri-linear interpolation of the interior nodes. For a 2D region, it causes four **res** commands to space nodes equally along each of the four edges, and then a **lin** command to bi-linearly interpolate the interior nodes.

lin Linear interpolation

lin *region*

Remarks

There is no need to specify linear interpolation on a simple edge, face, or solid region; that is, on any of the smallest regions that you can specify. That is because linear interpolation is the default interpolation method. Normally you will want to use this command on a region which consists of several simple regions. This command is essentially a command to ignore certain partitions between regions. You must take care to select the correct type of interpolation for your task. You may need to specify linear interpolation along the edges of a multiple facial region before doing a linear interpolation on the whole face. You may want to interpolate faces of a solid region before doing its interior.

This interpolation within the part's coordinate system. Thus interpolation is done in Cartesian coordinates for a **block** part and cylindrical coordinates for a **cylinder** part. For the cylinder part, the interpolated mesh lines will be curved rather, unless the angular coordinates of the boundaries happen to be the same.

When you specify an edge of the mesh to be linearly interpolated, the nodes in the interior of the edge will be distributed to obey the rule specified by the **res**, **drs**, **as**, **das**, or **nds** command. For example:

Examples: `block 1 6 16;1 6;-1;1 8 16 1 6 0`

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

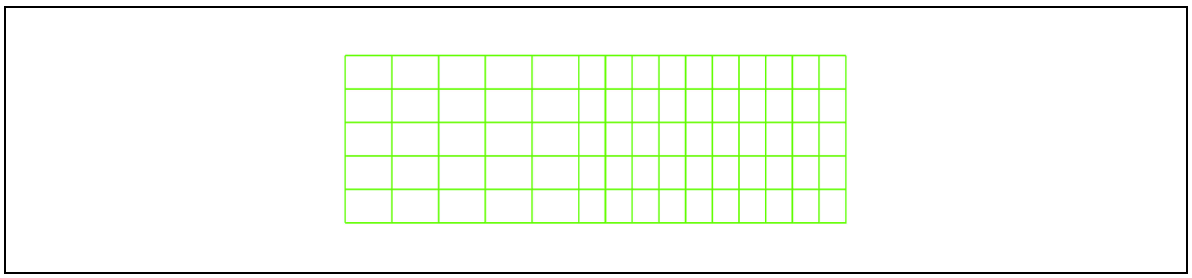


Figure 255 Two independent blocks

```
lin 1 2 1 3 2 1
```

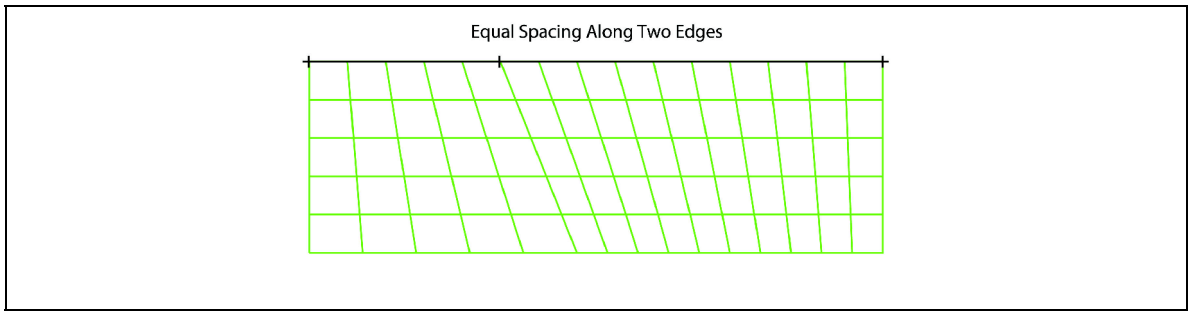


Figure 256 Interpolation Across 2 Regions

```
res 1 2 1 3 2 1 i .9
```

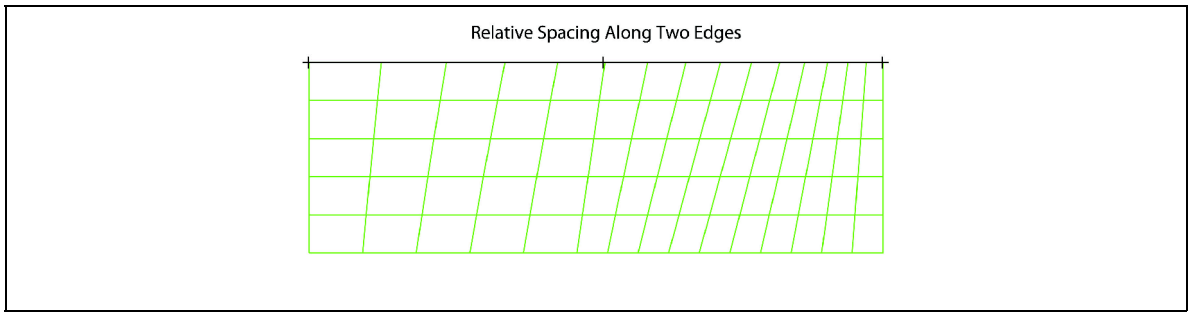


Figure 257 Spacing Across 2 Regions

When you specify a face of the mesh, a modified bi-linear interpolation positions the interior nodes of the face. This interpolation is based on the positions of the nodes along the edges of the face. The boundary edge nodes are not moved.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

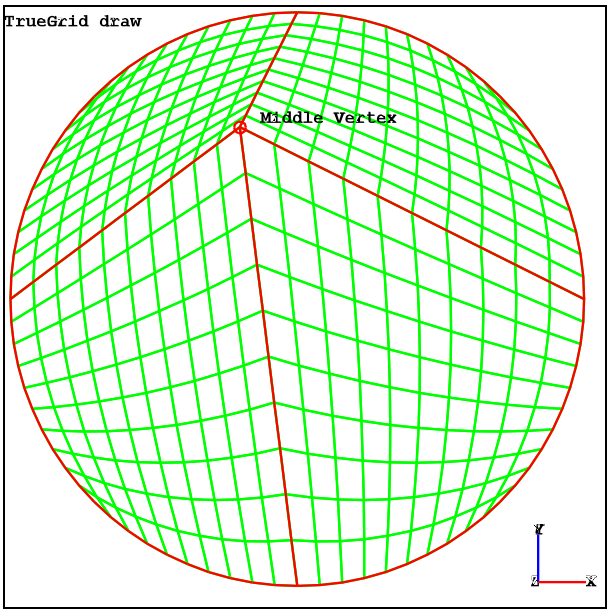


Figure 258 Four Independent Regions

Example

```
sd 1 cy 0 0 0 0 0 1 1
block 1 11 21;1 11 21;-1;
      -1 0 1 -1 0 1 0
pb 2 2 1 2 2 1 xy -0.2 0.6
sfi -1 0 -3; ; ;sd 1
sfi ;-1 0 -3; ;sd 1
lini ;;-1;
```

When you specify a solid region, a modified tri-linear interpolation positions the interior nodes of the region. This interpolation is based on the positions of the nodes along the faces of the region. These face nodes are not moved; neither are the edge nodes of the region.

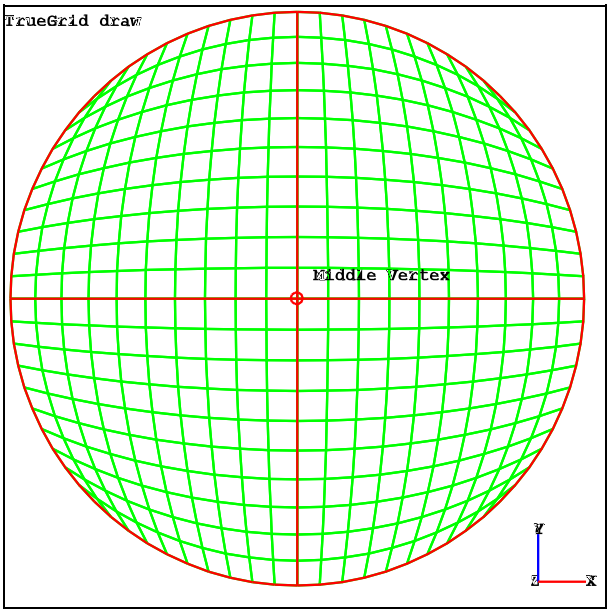


Figure 259 Interpolated like a Single Region

Algorithm

Linear interpolation can be applied along an edge between two end nodes, a modified bi-linear interpolation of a face of the mesh between four edges, and a modified tri-linear interpolation through a volume of the mesh between six faces. The order of the interpolations and their interdependencies are discussed in the Introduction and in the section describing the command hierarchy.

This multi-dimensional interpolation is a modification of the tensor product of linear interpolation. In the 1D case, node are interpolated along a line between two end points, so as to satisfy the relative

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

spacing rule[4]. In the 2D case, a modified bi-linear method interpolates interior nodes from the four boundary edges of the face of a mesh. In the 3D case, a modified tri-linear method interpolates the interior nodes from the six boundary faces of a three-dimensional rectangular region of the mesh. The following is an exact description of the interpolation method for the interior of a two-dimensional region.

In the following, *i*,*j*,*k* will represent computational space coordinates (see the Introduction); *x*,*y*,*z* will represent physical space coordinates; and X will represent the vector of all three physical space coordinates, X = (*x*,*y*,*z*). Normally we will think of this vector X as depending on the computational coordinates, X = X(*i*,*j*,*k*).

Consider a face where the i-index ranges from i_m to i_x, the j-index ranges from j_m to j_x, and the k-index is constant. Suppose that the face's boundary edges are already computed using the linear interpolation. In order to compute the physical space coordinates (x,y,z) = X(i,j,k) of an interior node (i,j,k), the algorithm uses eight known boundary coordinates: $X(i_m,j_m,k)$, $X(i_m,j,k)$, $X(i_m,j_x,k)$, $X(i,j_m,k)$, $X(i,j_x,k)$, $X(i_x,j_m,k)$, $X(i_x,j,k)$, and $X(i_x,j_x,k)$. The interpolation of these eight points to X(i,j,k) is based on the interpolating parameters:

$$a = \frac{i - i_m}{i_x - i_m} \qquad \text{and} \qquad b = \frac{j - j_m}{j_x - j_m}$$

In addition, define

d = distance from $X(i_m,j,k)$ to $X(i_x,j,k)$
d_m = distance from $X(i_m,j_m,k)$ to $X(i_x,j_m,k)$
d_x = distance from $X(i_m,j_x,k)$ to $X(i_x,j_x,k)$
e = distance from $X(i,j_m,k)$ to $X(i,j_x,k)$
e_m = distance from $X(i_m,j_m,k)$ to $X(i_m,j_x,k)$
e_x = distance from $X(i_x,j_m,k)$ to $X(i_x,j_x,k)$

[4] The default relative spacing rule is for nodes to be equally spaced. You can set the relative spacing rule with **res drs**, **as**, **das** or **nds**.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

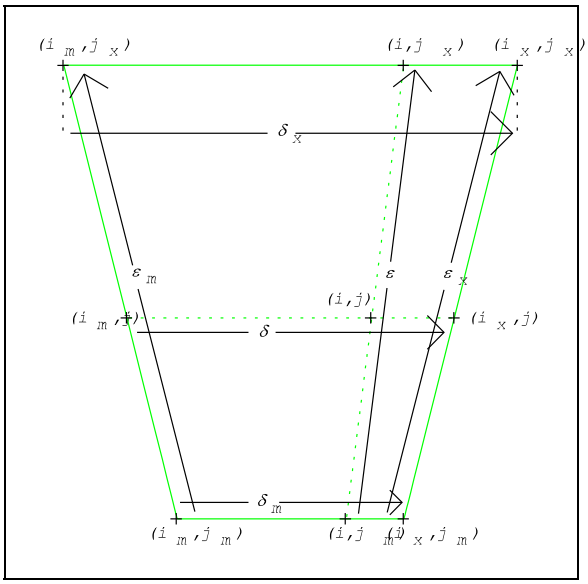


Figure 260 Modified Bi-Linear Definitions

The most straightforward bi-linear interpolation would be

$$X(i,j,k) = -(1-a)(1-b)X(i_m,j_m,k) - a(1-b)X(i_x,j_m,k) - ab X(i_x,j_x,k) - (1-a)bX(i_m,j_x,k) + (1-a)X(i_m,j,k) + aX(i_x,j,k) + (1-b)X(i,j_m,k) + bX(i,j_x,k)$$

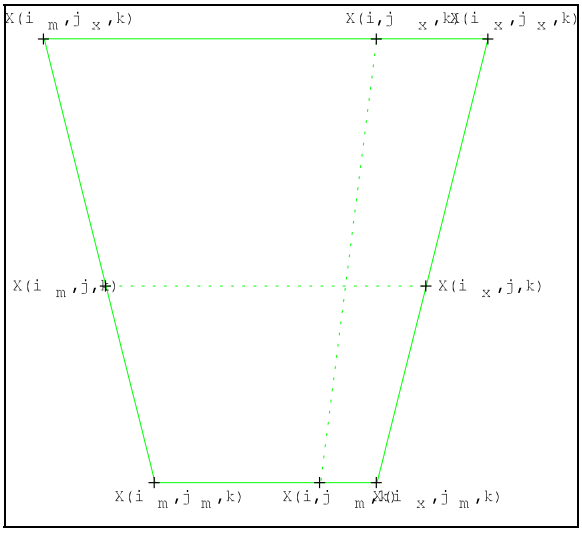


Figure 261 Effective Boundary Coordinates

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This can be a problem when nodes are clustered toward the corners in both directions. The example below uses this method which interpolates the interior nodes outside the convex boundary.

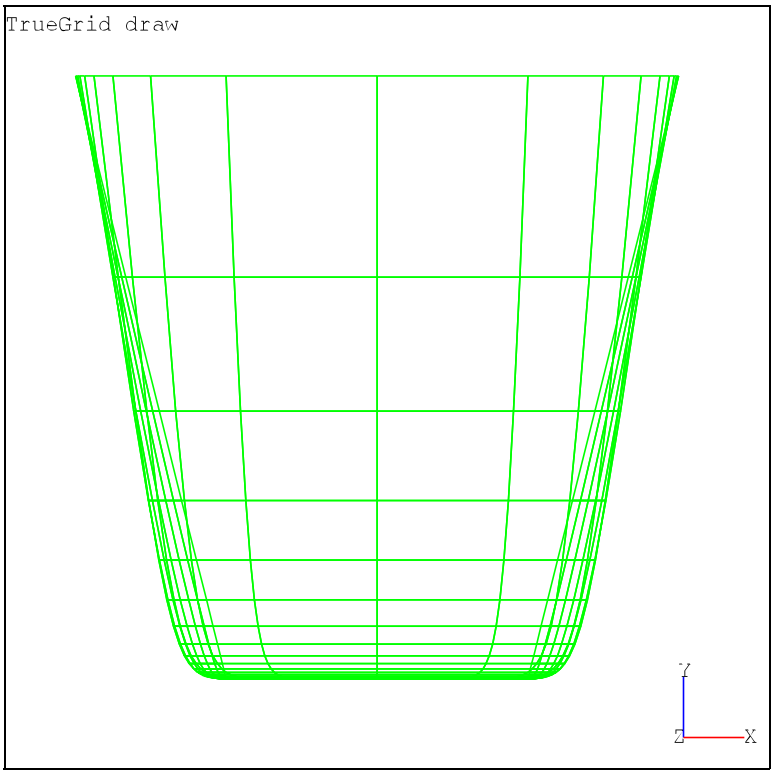


Figure 262 Pathology Of Bi-Linear Interpolation

But **True*Grid*®** does not do that when a middle distance, d or e, is less than an edge distance, d_m, d_x, e_m, or e_x. In these cases, it scales down some of the last four terms of the above equation, as follows. Let $c=d/d_m$ and if $c<1$ define

$$W_{jm} = (1-c)((1-a)X(i_m,j_m,k) + aX(i_x,j_m,k)) - cX(i,j_m,k)$$

and otherwise, let

$$W_{jm} = X(i,j_m,k)$$

In a similar fashion, let $c=d/d_x$ and if $c<1$ then define

$$W_{jx} = (1-c)((1-a)X(i_m,j_x,k) + aX(i_x,j_x,k)) - cX(i,j_x,k)$$

and otherwise, let

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

$$W_{jx} = X(i, j_x, k)$$

Next, define similar equations for the i-index. Let $c=e/e_m$ and if $c<1$ then define

$$W_{im} = (1-c)((1-b)X(i_m, j_m, k) + bX(i_m, j_x, k)) - cX(i_m, j, k)$$

and otherwise, let

$$W_{im} = X(i_m, j, k)$$

Last, let $c=e/e_x$ and if $c<1$ then define

$$W_{ix} = (1-c)((1-b)X(i_x, j_m, k) + bX(i_x, j_x, k)) - cX(i_x, j, k)$$

and otherwise, let

$$W_{ix} = X(i_x, j, k)$$

Then the formula for the new coordinates of the interior node is

$$\begin{aligned} X(i,j,k) = & -(1-a)(1-b)X(i_m, j_m, k) - a(1-b)X(i_x, j_m, k) \\ & - abX(i_x, j_x, k) - (1-a)bX(i_m, j_x, k) \\ & + (1-a)W_{im} + aW_{ix} + (1-b)W_{jm} + bW_{jx} \end{aligned}$$

In the example above, some of the effective boundary coordinates would be modified using this method.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This modified bi-linear interpolation method compensates for large differences between opposite edges of a face of the mesh. In case the spacing rule is severe in both directions, this modified method avoids interpolating inverted elements. In milder circumstances, this method produces a slightly more pleasing interpolated surface.

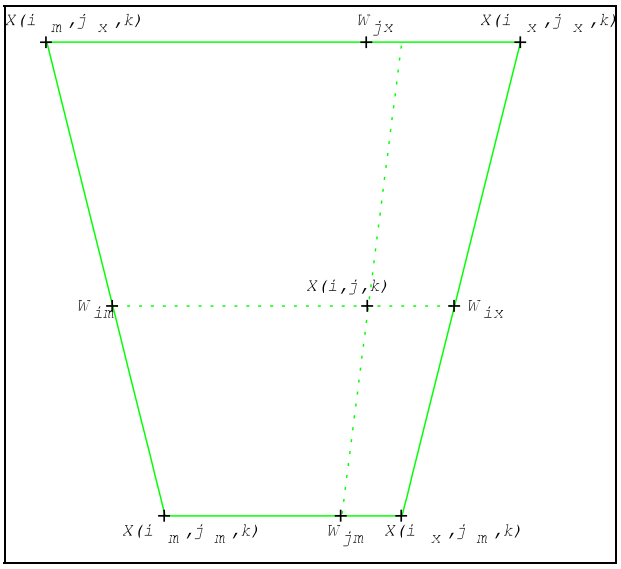


Figure 263 Modified Effective Boundary Coordinates

```
block 1 21;1 21;-1;-1 1 -1
1 0
tr 1 1 1 2 1 1 xsca .5 ;

res 1 1 1 2 2 1 j 1.5
drs 1 1 1 2 2 1 i 2 2
```

The interpolation for the 3D solid case is the obvious generalization of this method.

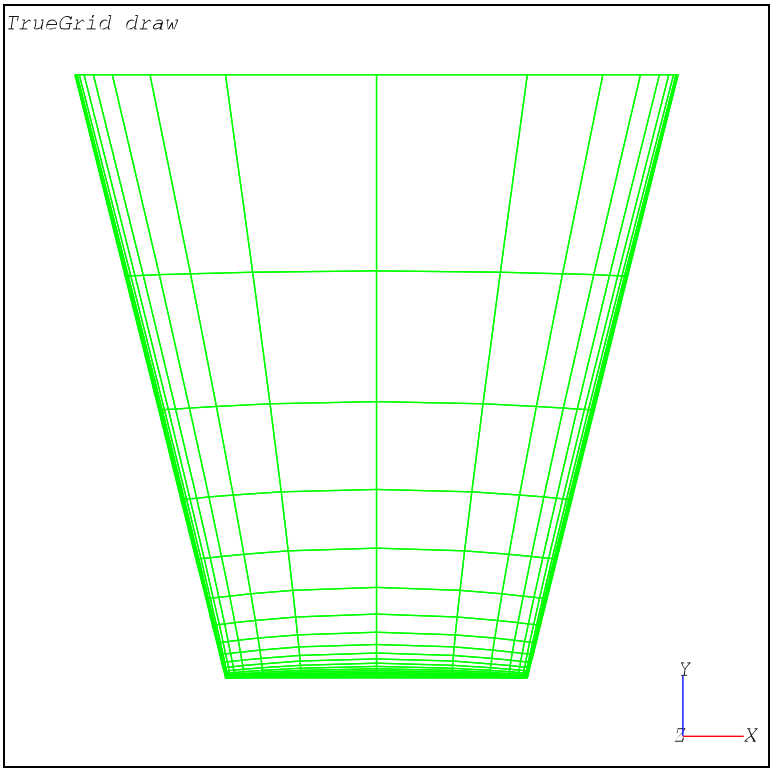


Figure 264 Modified Bi-Linear Interpolation

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

lini Linear interpolation by index progression

lini *progression*

Remarks

This computes the mesh in a progression by linear interpolation, the default method. **Lini** and **lin** are related the usual way that a command for progressions is related to a command for regions. You could replace one **lini** command with a number of **lin** commands by breaking the progression into a number of regions and applying **lin** separately to each of the regions. See the discussion of **lin** on the preceding pages.

relax Equipotential relaxation

relax *region {& region} iterations min_change weight*

where

iterations	is the maximum number of iterations to use,
min_change	is an absolute error tolerance (there will be no more iterations if, in the last iteration, no coordinate was moved by more than *min_change* in any zone)
weight	is an interpolation weight factor (the value 1.0 usually works)

Remarks

The numerical method is an adaptation of one described by Alan M. Winslow in his report "Equipotential Zoning of Two-Dimensional Meshes", UCRL-7312, University of California. The method treats the mesh lines as contours of the solution to a system of Laplace equations, where the boundary nodes form boundary conditions. By setting the command's arguments, you can choose to iterate until the method converges, or you can choose to do just a few iterations. It is best to experiment with this command to get the desired results.

When a face of the mesh is specified, then all interior face nodes are relaxed. If a node is on the boundary or if it is next to a region that has been deleted (see **de)**, it will not be relaxed. It is best to project the face onto a surface before using this command. Relaxed nodes will be constrained to the surfaces they are projected onto.

If an interior face node is projected to several surfaces, it will remain on the intersection of the surfaces. For example, if a node is required to be along the curve of intersection of two surfaces, it will be relaxed while constrained along that curve. Since boundary nodes are not moved, the nodal distributions along these edges will be preserved. Zoning due to the **res**, **drs**, **as**, **das**, or **nds** commands for interior edges will not be preserved.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Multiple faces can be specified using the ***&*** between region specifications. For example, the three faces of a corner can be specified: an i-face, a j-face, and a k-face. All of the nodes including the three interior edges and the corner node will be relaxed. Disjoint faces can be relaxed together. If the edge of one face is glued to the edge of another face using the intra-part BB command, then the coincident nodes along the common edge will also be relaxed. If three, four, or five faces are glued together and share a common node in the center, that center node will be relaxed as well.

When a volume is relaxed, no interior surface projections or edge node distributions are preserved. As with face relaxations, any node on the boundary or next to a region that was deleted (see **de**) will not be relaxed.

The weight factor is used to interpolate between the old nodal coordinates and the new within each iteration of the relaxation. If it is set to 1.0, then the new value is used. If it is set to a smaller number, then a point is interpolated between the new and old coordinates of a node. The interpolation parameter makes it possible to slow or speed up the convergence to the Laplace solution. In most cases, 1.0 will be a satisfactory value.

The **relax** and **relaxi** commands are all executed after the **tf** and **tfi** commands. These commands are executed in their relative order.

Examples

```
block 1 11;1 11 21;-1;
      0 1 0 1 2 2
pb 1 2 1 1 2 1 xy 3.22 1.69
pb 2 3 1 2 3 1 xy 2.50 1.21
pb 1 3 1 1 3 1 xy .596 3.93
relax 1 1 1 2 3 1 30 .00001 1
```

This example shows that the relaxation can cross the initial region boundaries. Notice that the mesh lines hug the concave boundaries and pull away from convex boundaries.

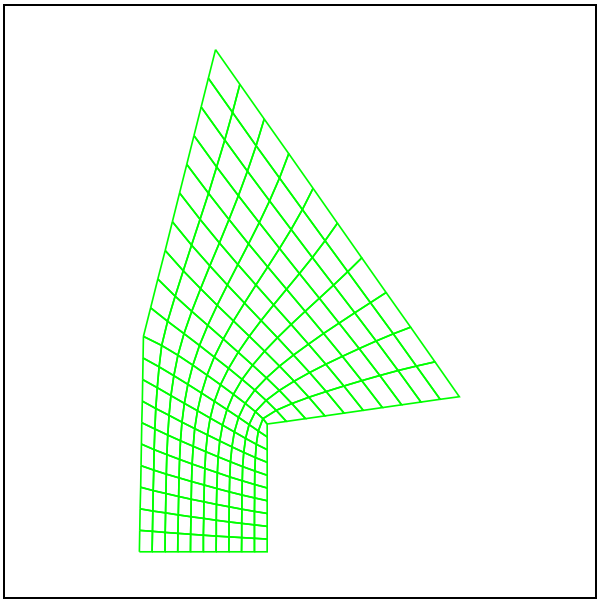


Figure 265 Simple Relaxation

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

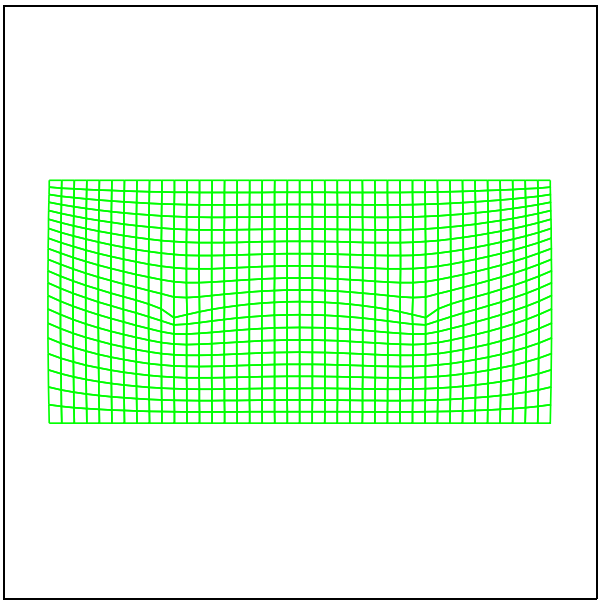


Figure 266 Relaxation with interior constraints

```
sd 1 sp 2.5 2.5 2.5 4
sd 2 cy 2.5 2.5 0 0 0 1 1.25
block 1 11 21 31;1 11 21 31;
      -1;1 2 3 4 1 2 3 4 4
dei 2 3; 2 3; -1;
sfi ;; -1; sd 1
sfi 2 3; 2 3; -1; sd 2
relax 1 1 1 4 4 1 30 .0001 1
```

The nodes that form the interior hole act like a boundary condition to the relaxation.

```
sd 1 cy 0 0 0 1 0 0 4
sd 2 cy 0 -4 0 0 0 1 4
sd 3 plan -1 0 0 1 0 0
sd 4 plan 1 0 0 1 0 0
block 1 11 31 41;1 11 21;-1;-2 -1 1
2 -1 0 1 4
sfi ;; -1; sd 1
sfi 2 3; -2; -1; sd 2
sfi -2; -2; -1; sd 3
sfi -3; -2; -1; sd 4
relax 1 1 1 4 3 1 40 .0001 1
res 4 1 1 4 3 1 j 0.95
res 1 1 1 1 3 1 j 0.95
```

This example shows that interior projections are maintained with relaxation.

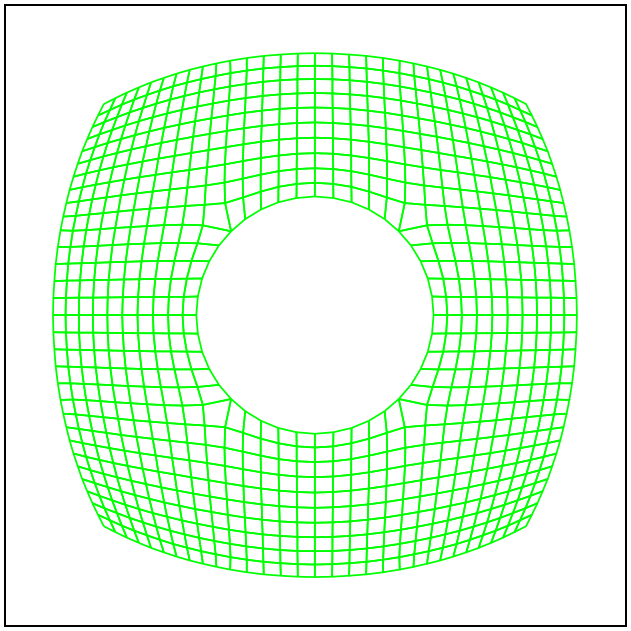


Figure 267 Relaxation around a hole

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

relaxi Equipotential relaxation

relaxi *progression iterations min_change weight*

where

iterations is the maximum number of iterations to use,

min_change is an absolute error tolerance (there will be no more iterations if, in the last iteration, no coordinate was moved by more than *min_change* in any zone)

weight is an interpolation weight factor (the value 1.0 usually works).

Remarks

relaxi and **relax** are related the usual way that a command for progressions is related to a command for regions. You could replace one **relaxi** command with a number of **relax** commands by breaking the progression into a number of regions and applying **relax** separately to each of the regions. When several faces or volumes are specified in one index progression, then each face or volume is relaxed independently of the others. See the discussion of **relax** on the preceding pages.

splint Interpolate edges along cubic splines

splint *region direction derivative_flag [derivatives]*

where

direction can be i, j, or k

derivative_flag can be

- 00 to use a natural derivative at each endpoint
- 10 to specify derivatives at the minimum index endpoint(s)
- 01 to specify derivatives at the maximum index endpoint(s)
- 11 to specify derivatives at all endpoints

derivatives consist of as many 3D vectors as required (either none, 1 or 2)

Remarks

The **splint** command is a shortcut command which turns block edges into cubic spline curves. The control points for the curves are the vertices (block corners). There is no counterpart command for a block face which will turn the entire face into a cubic spline surface. However, this is nearly the case because spline interpolation can be applied in two or three directions simultaneously.

Instead of making 3D cubic spline curves and then placing edges along these curves, this command creates the cubic spline curves on the fly using the vertices as control points, and then places the mesh edges on these curves. Changing a vertex will automatically change the shape of the spline curves.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Derivatives at the endpoints can be set, or the "natural spline" can be used (where the second derivatives are 0 at the endpoints). There is no periodic feature for this command.

Be careful about using this command with the various spacing commands. If you apply spline interpolation to an edge, and then a command such as **res** (relative spacing) to the same edge, then the intermediate vertices are forced to slide along the spline curve to satisfy the spacing rules. This results in a situation where the vertices are no longer located at the control points of the spline. In this case, moving a vertex can have startling results since a small change in the location of a vertex from where it appears may actually result in a large change in the control points of the spline. Therefore, it is recommended that no spacing commands be used with **splint** until the desired shape has been achieved. As a result of this limitation, this command has only limited applicability.

tf Transfinite interpolation

tf *region*

Remarks

You can apply transfinite interpolation to a face or a block of the mesh. Both the face and the block can cross partitions in the mesh. However, if interior edges or faces, respectively, have been projected to surfaces, those projections will be ignored.

This method best preserves the relative spacing in the boundaries throughout the interior. For best results in a 3D solid region, apply the transfinite interpolation to the six exterior faces of a 3D solid region and the 3D solid region.

Algorithm

This is the best algebraic mesh interpolation methods. It is very sensitive to the shape of the boundary edges and the distribution of the nodes along the edges.

The boundary spacing is mapped to relative arc length spacing ranging from 0.0 to 1.0. Then it interpolates all interior coordinates in the relative arc length field. Each node is projected to the boundaries, in the relative arc length coordinates, and uses that projection to get the projection of each node onto the actual boundaries. Finally, it uses the node's relative arc length coordinates to interpolate the actual projected boundary coordinates. This is explained in more detail below.

The first step in the transfinite interpolation algorithm is to position the edge nodes of the face of the mesh, that is, compute the mappings between computational space and physical space for the edges. Edges may be interpolated (the **lin** command) and projected to surfaces (the **sf** command) with the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

spacing between nodes controlled using the **res**, **drs**, **as**, **das**, or **nds** commands. An example will be used throughout this discussion. It is generated using the following commands:

```
sd 1 sp 0 0 0 2
sd 2 cy 0 -3 0 0 0 1 1.5
block 1 6;1 6;-1;-1 1 -1 1 1
sfi ;; ; sd 1 sfi ; -1; ; sd 2
res 1 1 1 1 2 1 j 1.5
pb 2 2 1 2 2 1 xyz 0.747134 0.793349 1.15470
tfi ;;-1;
```

In the next picture, only the edges of the face are shown. This is the initial condition for the transfinite interpolation.

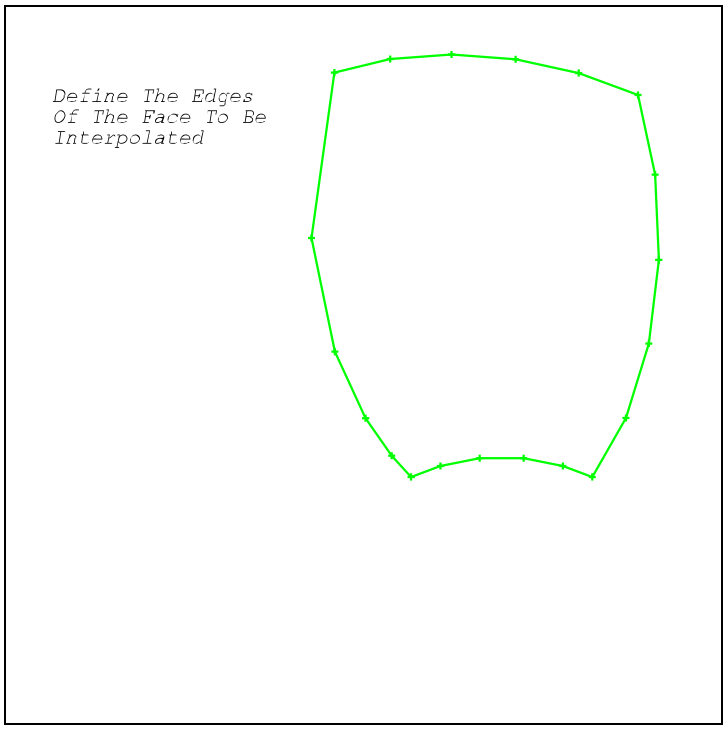


Figure 268 Boundary Edges Of A Face

The second step is to compute a mapping between computational space and relative arc length space for the edges. Let the endpoints of an edge have indices of 0 and N in the computational space and P_0 and P_N in the physical space. These indices are actually coordinates in the computational space. 0 and N in the computational space are mapped to 0 and 1 in relative arc length space respectively. For each interior edge node i in computational space located at P_i in physical space the arc length $|P_i\text{-}P_0|_a$ from P_0 to P_i along the edge is calculated, and node i is mapped to the position with a distance $r_i = |P_i\text{-}P_0|_a \,/\, |P_N\text{-}P_0|_a$ from the previous node.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

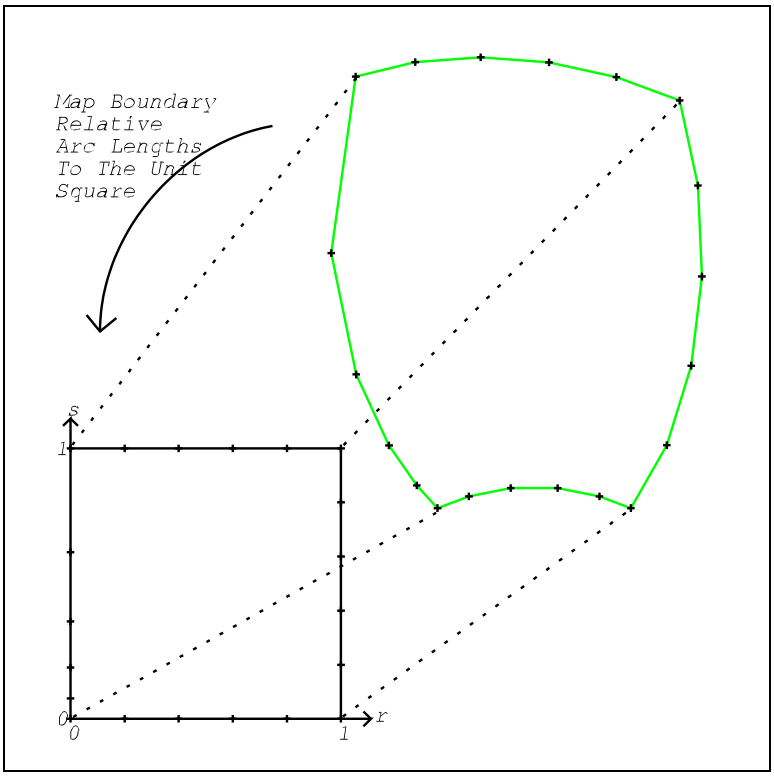


Figure 269 Boundary Relative Arc Lengths

The third step is to extend the second step's mappings to the interior nodes. Consider a face node (i,j) in the computational space. There are four corresponding edge nodes, $(i,0)$, (i,M), $(0,j)$, and (N,j). The coordinates of the edge nodes in relative arc length space, $(r_0,0)$, $(r_1,1)$, $(0,s_0)$, and $(1,s_1)$ are known. The face node coordinates (r,s) in relative arc length space satisfy:

$$r = (1-s)r_0 + sr_1$$
$$s = (1-r)s_0 + rs_1$$

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

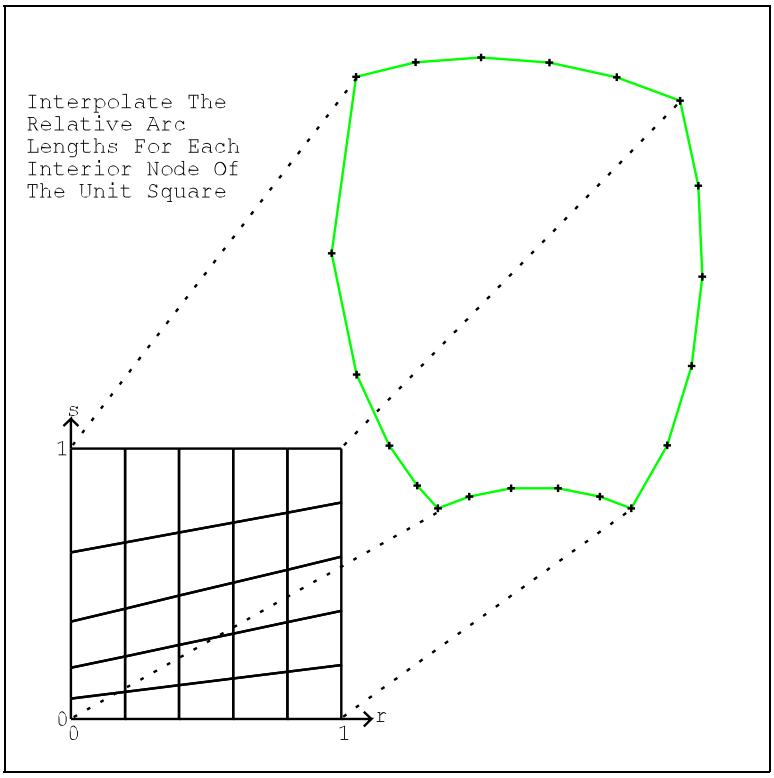


Figure 270 Domain interior nodes interpolated

The fourth step is to map each surface node from relative arc length space to physical space. Each interior node at a point (r,s) is mapped to the physical space using the bilinear interpolation based on the eight relevant boundary nodes: the four corner nodes and four edge nodes, (0,0), (0,1), (1,0), (1,1), $(r,0)$, $(r,1)$, $(0,s)$, $(1,s)$. If these nodes map to coordinates X_{00}, X_{01}, X_{10}, X_{11}, X_{r0}, X_{r1}, X_{0s}, and X_{1s} in physical space, then (r,s) will be mapped to X_{rs}, where:

$$X_{rs} = ((1-r)X_{0s} + rX_{1s}) - (1-s)((1-r)X_{00} + rX_{10} - X_{r0}) - s((1-r)X_{01} + rX_{11} - X_{r1})$$

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

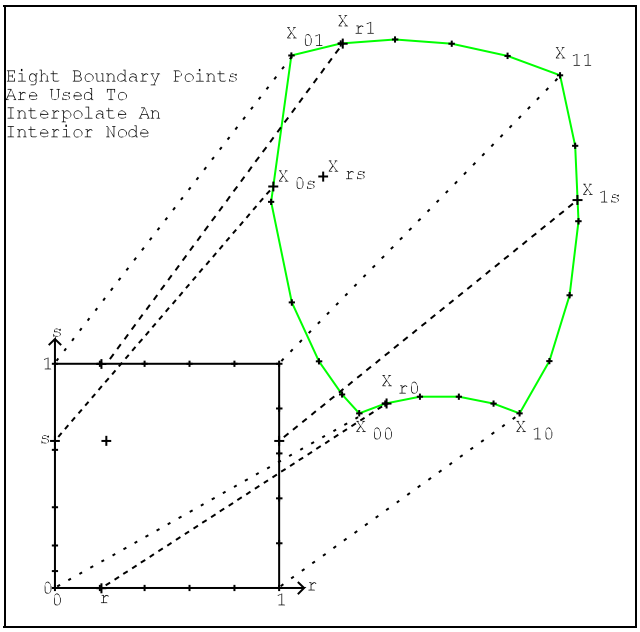


Figure 271 Interpolation From Eight Boundary Points

The result in the example is:

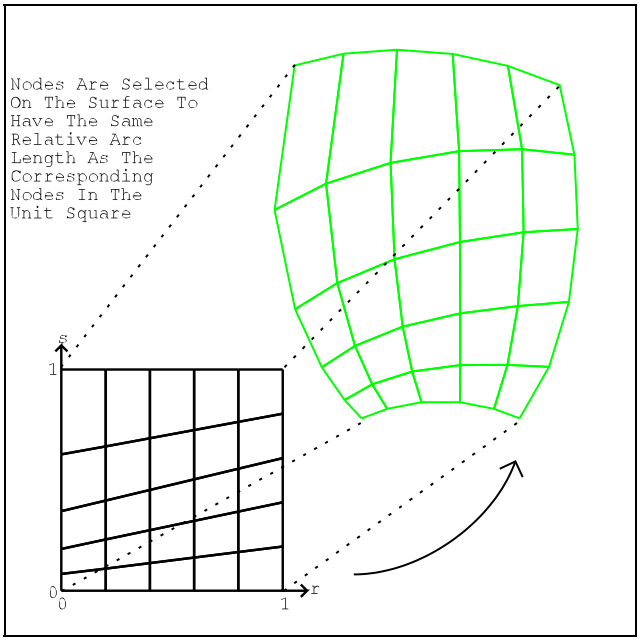


Figure 272 Interpolated Face

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

In some cases, the transformation from physical space to relative arc length space can be many-to-one; that is, there might be interior folding of the face from the relative arc length field. In this case, the mesh is relaxed or smoothed a little to avoid the fold.

A face can be transfinitely interpolated and projected onto a surface. Since the edges of the face are projected to the surface first, conforming to the relative spacing rules invoked, the transfinitely interpolated face from these edges may conform closely to the shape of the projection surface. In this case, the properties of the transfinite interpolation will be preserved after each node has been moved the short distance to the actual projection surface.

References

Gordon, William J. and Theil, Linda C., "Transfinite Mappings and Their Application to Grid Generation", in *Numerical Grid Generation*, ed. Joe F. Thompson, North-Holland, 171, 1982.

Thompson, Joe F., Warsi, Z. U. A. , and Mastin, C. Wayne, *Numerical Grid Generation Foundations and Applications*, North-Holland, 310, 1985.

tfi Transfinite interpolation, by index progression

tfi *progression*

Remarks

tfi and **tf** are related the usual way that a command for progressions is related to a command for regions. You could replace one **tfi** command with a number of **tf** commands by breaking the progression into a number of regions and applying **tf** separately to each of the regions. When several faces or volumes are specified in one index progression, then each face or volume is interpolated independently of the others. See the discussion of **tf** on the preceding pages.

tme Thomas-Middlecoff relaxation

tme *region iterations min_change weight*

where

iterations	is the maximum number of iterations to use
min_change	is an absolute error tolerance (there will be no more iterations if, in the last iteration, no coordinate was moved by more than *min_change* in any zone)
weight	is a the interpolation weight factor (use 1.0 if you don't need this feature)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

Thomas-Middlecoff relaxation improves the mesh by solving a set of Poisson elliptic differential equations, which is described in the following reference. This relaxation method does a very good job of propagating an edge's distribution of nodes into the interior of the mesh. It also tries to approximate an orthogonal mesh near the boundaries.

These commands are executed after all **relax** and **relaxi** commands are executed. The **tme** and **tmei** commands are executed in the relative order that you specified them.

The interpolation weight factor amplifies iterations that solves the Poisson equation. In most cases, use 1.0. In each iteration, a candidate coordinate is computed for each node. It computes the node's new coordinate position by averaging this candidate with the old position. The weight factor determines how much of the old position to use. If the weight is 1.0, then the old position is not used at all. When you make the weight smaller, the candidate position becomes less important and the old position becomes more important in determining the node's new coordinate position.

Sometimes it is best to let this method iterate until it converges. In other cases, it is preferable to iterate only a few steps to smooth the mesh, but not alter its global features. When the number of iterations is made small and the interpolation factor kept small, the effect can be almost imperceptible. It is best to experiment with this method.

When a face is specified, there can be no holes in the interior of the face. This method uses the boundary edge nodes as the boundary condition. The coordinates within the interior of the face are treated as a first guess to the solution to the elliptic partial differential equations referenced above. Projection to surfaces are preserved as the mesh is smoothed.. Any controlled zoning on the interior using the **res**, **drs**, **as**, **das**, or **nds** command will be lost due to the relaxation.

When a volume is specified, there can be no holes in the interior of the volume due to deletions. This method uses the boundary face nodes as the boundary condition. The coordinates within the interior of the volume are treated as the initial guess to the solution to the elliptic partial differential equations referenced above. When a volume is relaxed using this method, the six bounding faces are not automatically relaxed.

References

P. D. Thomas and J. F. Middlecoff, "Direct Control of the Grid Point Distribution in Meshes Generated by Elliptic Equations", *AIAA Journal*, Volume 18, Number 6 (June, 1980), pages 652-656.

Examples

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

In the following examples, the various methods of interpolation and smoothing are compared. One edge is smooth while the opposite edge has a corner. Most interpolations have difficulty with extreme concave or extreme convex boundaries. **Esm** can be tailored to avoid this problem. Some of the methods (**lin** and **tfi**) are purely algebraic and the shape of corner on the boundary is reflected through the mesh. The elliptic methods tend to smooth the corner. The **relax** and **esm** commands attempt to give uniform elements while the **lin**, **tfi**, and **tme** commands try to preserve the boundary nodal distribution throughout the interior.

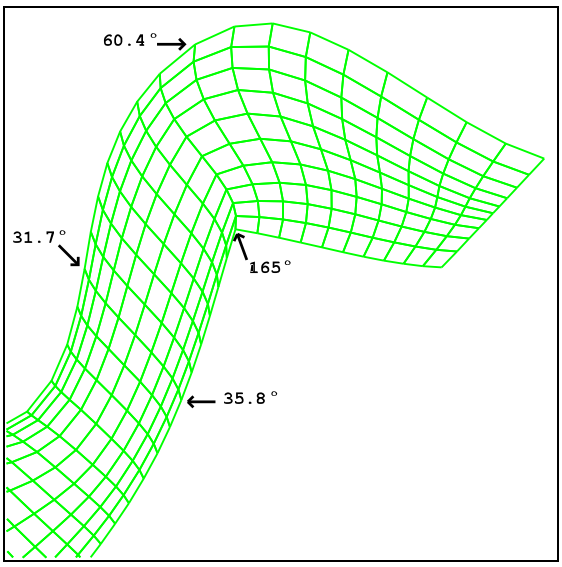


Figure 273 Lin over 3 blocks

```
sd 1 cy 0 0 0 1 0 0 1
block 1 11 21 31;1 11;-1;
      0 1 2 3 -.5 .5 1
pb 1 2 1 1 2 1 xyz 0 .45 .89
pb 2 2 1 2 2 1 xyz .87 -.51 .86
pb 3 2 1 3 2 1 xyz 2.3 .44 .9
pb 4 2 1 4 2 1 xyz 3.4 -.91 .41
pb 1 1 1 1 1 1 xyz -.149 -1 .04
pb 2 1 1 2 1 1 xyz .96 -.93 .37
pb 3 1 1 3 1 1 xyz 2.1 -.47 .88
pb 4 1 1 4 1 1 xyz 2.73 -.95 .3
sfi ;; -1; sd 1
splint 1 2 1 4 2 1 i 00
das 1 1 1 4 2 1 j .1 .1
lin 1 1 1 4 2 1
tfi ;; -1;
```

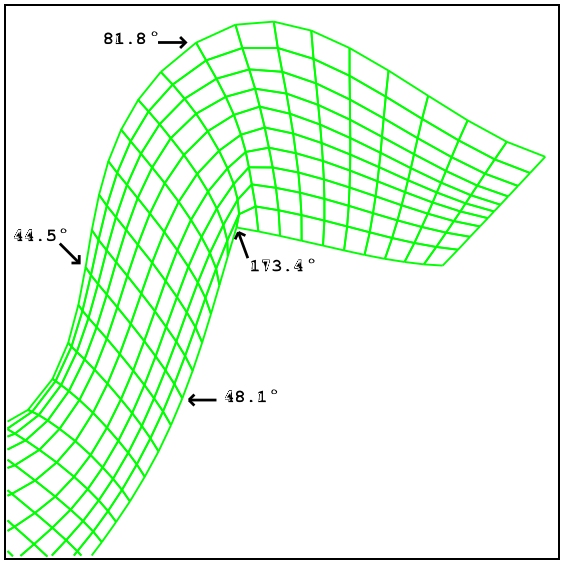


Figure 274 Tfi over 3 blocks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Many boundary angles are an improvement using the **tfi** over the **lin** command. However, there is no advantage with **tfi** near a sharp corner.

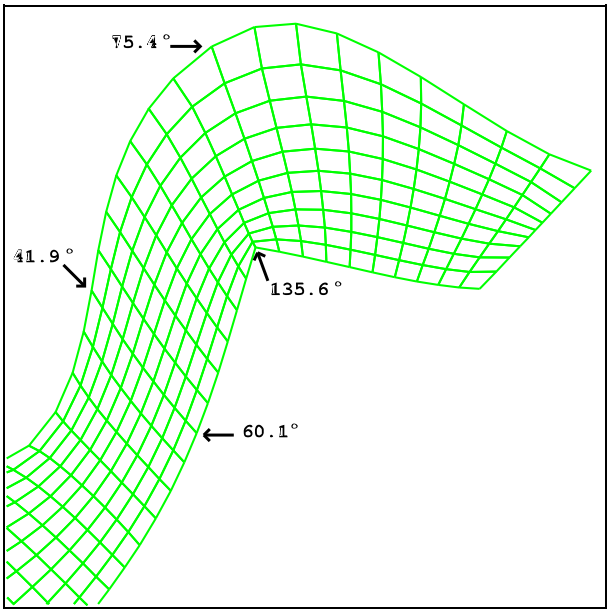


Figure 275 Relax over 3 blocks

```
relax 1 1 1 4 2 1 100 .00001 1
```

The **relax** command produces a smooth mesh around the sharp corner and many of the angles are better than the **tfi**. However, it converges to the concave part of the boundary and produces nearly equal elements. The nodal distribution on the boundary is ignored on the interior.

```
tme 1 1 1 4 2 1 100 .00001 1
```

Tme is better at propagating the boundary nodal distribution. It also concentrates the mesh near the corner where the boundary is concave. The angles are generally better than relax because **tme** was designed to produce a near orthogonal mesh near the boundaries. It does not try to produce equal elements. This is the best method for producing an orthogonal boundary layer for fluids.

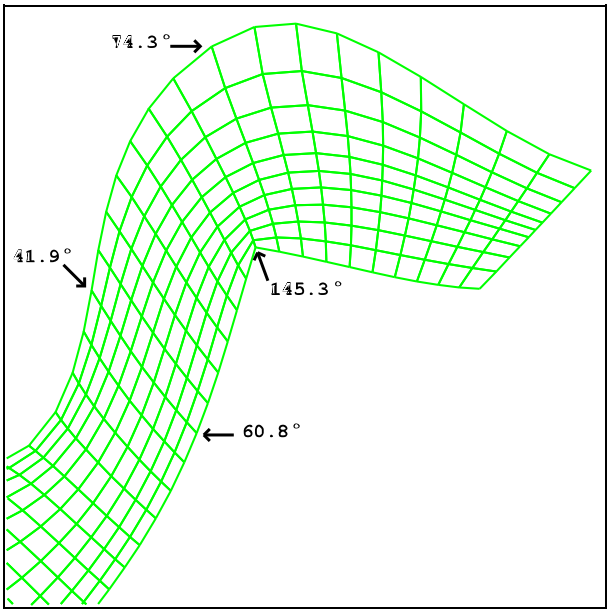


Figure 276 Tme over 3 blocks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

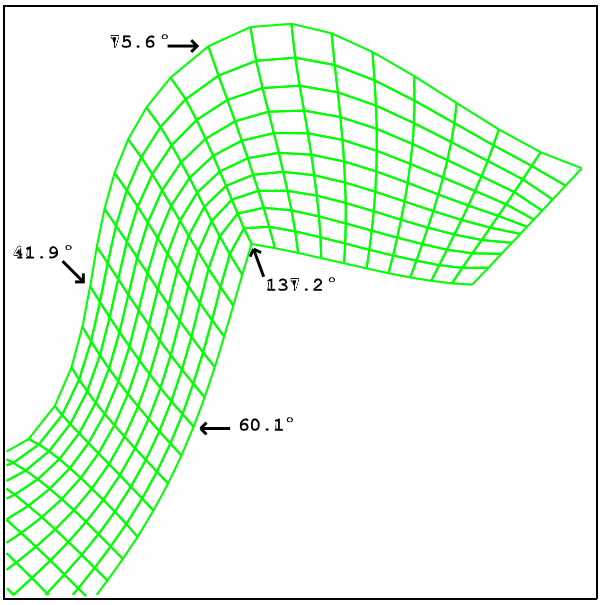


Figure 277 esm over 3 blocks

```
esmp 3 1 1 3 2 1 0 4 .75 5
esm 1 1 1 4 2 1 100 .001 1 .3 6;
```

The **esm** command produces a mesh with properties like **relax** except that you can control the nodal distribution on the interior edges of the mesh using the **esmp** command. In this example, a source was added to the elliptic differential equations being solved to force the mesh lines to move away from the sharp concave corner.

```
unifm 1 1 1 4 2 1 100 .00001 1
```

The uniform smoothing has many of the same characteristics of the relax smoothing with the important exception that it is not affected by curvature on the boundary. That is, it does not wander away from convex boundaries and it does not get drawn towards concave boundaries.

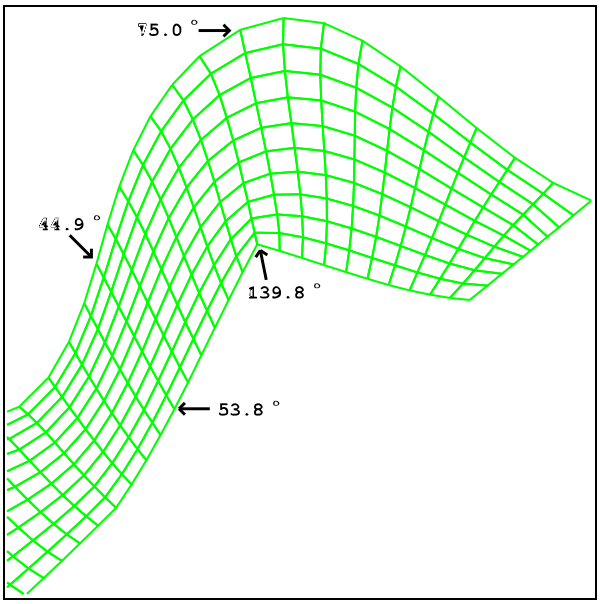


Figure 278 Unifm over 3 blocks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

tmei Thomas-Middlecoff relaxation, by index progression

tmei *progression iterations min_change weight*

where

iterations	is the maximum number of iterations to use
min_change	is an absolute error tolerance (there will be no more iterations if, in the last iteration, no coordinate was moved by more than *min_change* in any zone)
weight	is an interpolation weight factor (use 1.0 if you don't need this feature)

Remarks

tmei and **tme** are related the usual way that a command for progressions is related to a command for regions. You could replace one **tmei** command with a number of **tme** commands by breaking the progression into a number of regions and applying **tme** separately to each of the regions. When faces or volumes are specified in one index progression, then each face or volume is relaxed independently of the others. See the discussion of **tme** on the preceding pages.

neu Orthogonal boundary smoothing

neu *region switch*

where *switch* can be

ON	to activate the Neumann or orthogonality condition
OFF	to deactivate the Neumann or orthogonality condition

Remarks

This command identifies the regions of the mesh where the **unifm** or **unifmi** commands will satisfy the Neumann (or orthogonality) boundary condition instead of the Dirichlet condition. This command must be issued before issuing the **unifm** and **unifmi** commands. This command accumulates a set of boundary nodes in the part which are to be smoothed when a **unifm** or **unifmi** command is issued. The default is all boundary nodes are off. When a **unifm** or **unifmi** smoothing command is are, the set of nodes to receive the Neumann boundary condition is recorded. The nodes to receive this condition in the execution of the **unifm** or **unifmi** command cannot be changed once the **unifm** or **unifmi** command is issued. To change the nodes that are affected by the Neumann boundary condition, deactivate the **unifm** or **unifmi** command, use the **neu** or **neui** command to change the set of nodes to be affected, and then reissue the **unifm** or **unifmi** command.

At this time, the Neumann boundary condition is only affective when smoothing a 3D solid blocks.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This allows a boundary node to float along the projected surfaces, smoothing any nodal zoning or interpolation constraints. This is a departure from the way most interpolation and smoothing commands operate because it will allow the boundary nodes to move. These boundary nodes will be moved by the **unifm** or **unifmi** command to approximate an orthogonal boundary layer of elements. It can only an approximate an orthogonal boundary layer for several reasons. Most importantly, from a theoretical point of view, in most cases there does not exist a truly orthogonal mesh along the boundary. Also, this is an iterative method which slowly converges to the solution to the underlying differential equations. It is unlikely and not advisable to make this method converge because of the cost.

Example

This example compares uniform smoothing on the end faces of a cylindrical topology to the Neumann boundary condition. The unsmoothed mesh is generated from the following:

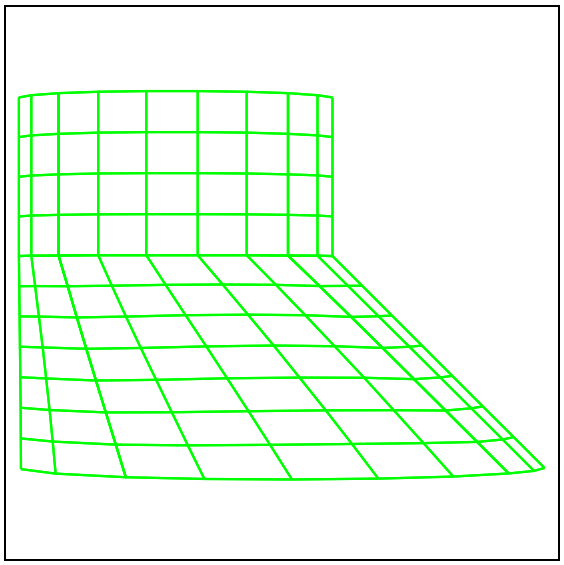


Figure 279 Exterior mesh

```
sd 1 cy 0 0 0 0 0 1 3
sd 2 function 0 360 0 1
 (1-v)*3*cos(u)+v*(2+5*cos(u));
 (1-v)*3*sin(u)+v*5*sin(u);
 4*v+3;;
sd 3 plan 0 0 0 0 0 1
sd 4 plan 0 0 7 0 0 1
block 1 3 8 10;1 3 8 10;1 5 12;
      -1 -1 1 1 -1 -1 1 1 0 3 7
dei 1 2 0 3 4; 1 2 0 3 4;;
mb 1 1 3 4 4 3 x 2
sfi -1 -4; -1 -4; 1 2;sd 1
sfi -1 -4; -1 -4; 2 3;sd 2
sfi ;; -1;sd 3
sfi ;; -3;sd 4
bb 1 2 1 2 2 3 1;bb 2 1 1 2 2 3 1;
bb 3 1 1 3 2 3 2;bb 3 2 1 4 2 3 2;
bb 3 3 1 4 3 3 3;bb 3 3 1 3 4 3 3;
bb 2 3 1 2 4 3 4;bb 1 3 1 2 3 3 4;
```

When the two end faces and the interior are smoothed with the uniform smoothing, the end faces are smoothed without regard to the shape of the interior. Then the interior is smoothed.

```
unifm 1 2 3 4 3 3 & 2 3 3 3 4 3 & 2 1 3 3 2 3 100 0 1 ;
unifm 1 2 1 4 3 1 & 2 1 1 3 2 1 & 2 3 1 3 4 1 100 0 1 ;
unifm 1 2 1 4 3 3 & 2 3 1 3 4 3 & 2 1 1 3 2 3 300 0 1 ;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

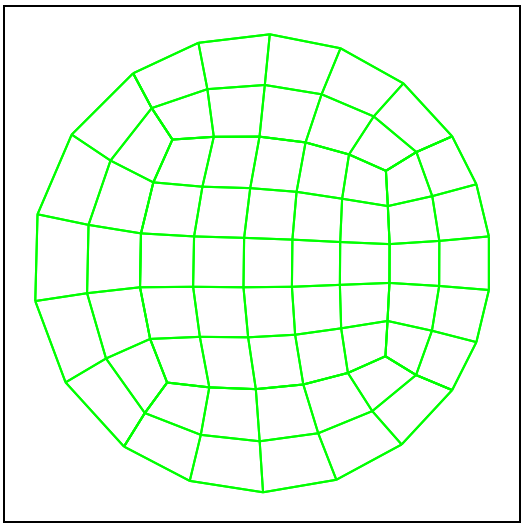


Figure 280 Large end smoothed

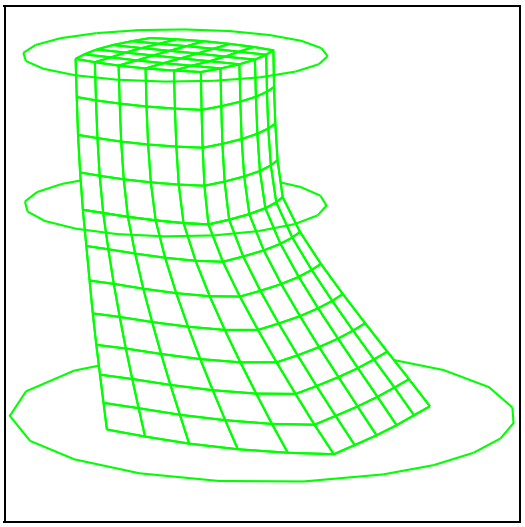


Figure 281 Interior blocks

The angles forming the elements in the middle blocks range from 50.9 to 127.3 degrees.

Alternatively, the Neumann boundary conditions are applied to the interior nodes of the top and bottom faces. Then only the interior is selected for smoothing.

```
neui ; ;-1 0 -3;on
neui -1 -4;-1 -4; ;off
unifm 1 2 1 4 3 3 & 2 3 1 3 4 3 & 2 1 1 3 2 3 300 0 1 ;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

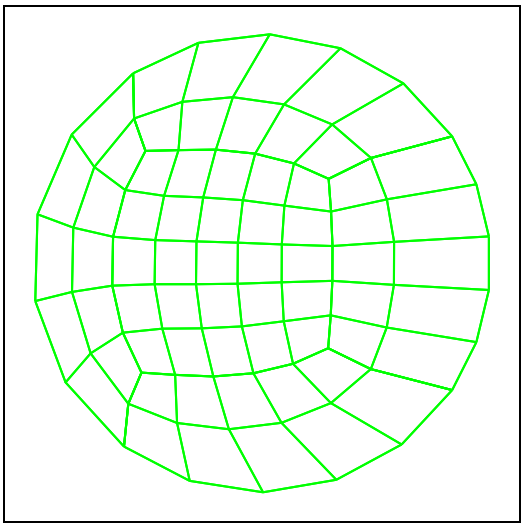


Figure 282 Large end w/ Neumann

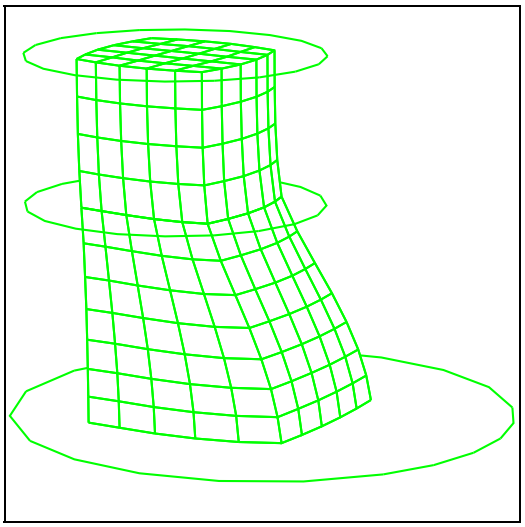


Figure 283 Interior blocks w/ Neumann

The angles in the middle blocks range from 62.9 to 119.4 degrees. The improvement is about 12 degrees, in worst case. When you reach this level of refinement, in the sense of improving the mesh quality, there is usually a price to pay for mesh improvements. Whenever there is curvature, some part of the mesh has to absorb that curvature by having distorted angles. At first, improvements are made with wise choices for the topology. This usually introduces irregular nodes where blocks meet. This is where the compromises in mesh quality begin. Then interpolation or smoothing methods are employed to diffuse the angular distortions in one manor or another. By using the Neumann boundary conditions with the uniform smoothing on this mesh, the angular distortions have been pushed to the outer blocks.

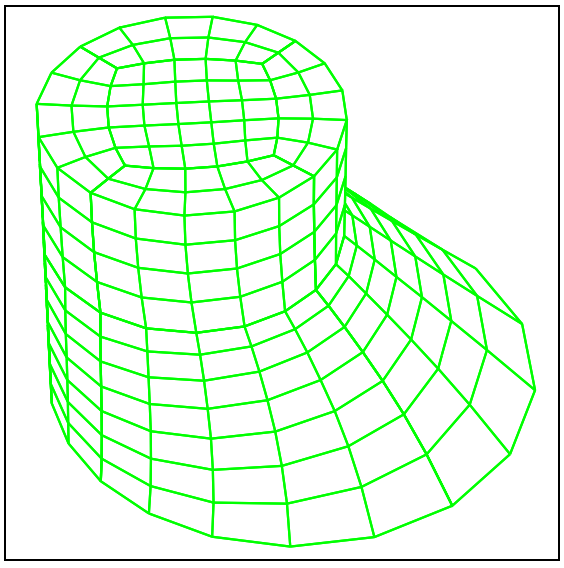


Figure 284 Neumann boundary everywhere

The angles in the outer blocks using uniform smoothing on the end faces range from 45.1 to 140.1 degrees. The angles in the outer blocks using the Neumann condition on the end faces range from 45 to 140.3 degrees. Although these differences in the outer blocks are not significant, larger differences can be found in other circumstances and they can be significant.

When the Neumann condition is applied to all nodes on the exterior, the quality of the interior blocks is hardly affected, ranging from 66.6 to 119.5 degrees.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

However, the exterior blocks produce mixed results with angles from 45.2 to 149.2 degrees. Also, seen in the picture of the mesh, the boundary changes in ways that may not be desirable. This too, demonstrates the principle that if you push on the mesh in one area to improve the quality, it will affect the quality in other regions.

neui Orthogonal boundary smoothing, by index progression

neui *progression switch*

where *switch* can be

on	to activate the Neumann or orthogonality condition
off	to deactivate the Neumann or orthogonality condition

Remarks

See the remarks for the **neu** command.

unifm Uniform smoothing

unifm *region {& region} iterations min_change weight*

where

iterations	is the maximum number of iterations to use,
min_change	is an absolute error tolerance (there will be no more iterations if, in the last iteration, no coordinate was moved by more than *min_change* in any zone)
weight	is an interpolation weight factor (the value 1.0 usually works)

Remarks

The numerical method is an adaptation of one described by Byung-Il Jun in his report "A Modified Equipotential Method for Grid Relaxation", UCRL-JC-138277, University of California. The method treats curvature differently than the method used in the **relax** command, producing a more uniform mesh. The boundary nodes form boundary conditions for the solution to a set of elliptic differential equations. By setting the command's arguments, you can choose to iterate until the method converges, or you can choose to do just a few iterations. It is best to experiment with this command to get the desired results. No holes are allowed in the interior.

A vertex, edge, or face may be formed from boundary nodes and still be considered as interior nodes for smoothing purposes. This is the reason for the option of specifying multiple regions in this command. Multiple faces or blocks can be specified using the **&** between region specifications. The

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

regions must be either all faces or all blocks. Disjoint regions can be smoothed together including the nodes at the interfaces. If the boundary of one region is glued to the boundary of another region using the intra-part **bb** command, then the coincident nodes along the interface will also be smoothed. If numerous regions meet at a single vertex which is completely surrounded by these regions, and if these regions are all glued to each other at the interfaces with the **bb** command, then that central vertex will be smoothed as well.

The weight factor is used to interpolate between the old nodal coordinates and the new within each iteration of the relaxation. If it is set to 1.0, then the new value is used. If it is set to a smaller number, then a point is interpolated between the new and old coordinates of a node. The interpolation parameter makes it possible to slow or speed up the convergence. In most cases, 1.0 will be a satisfactory value.

The **unifm** and **unifmi** commands are all executed after the **tf** and **relax**, **esm**, and **tme** commands. The **unifm** and **unifmi** commands are executed in their relative order.

Examples

This first example demonstrates the quality of smoothing within a cylindrical mesh. This is a slice through the middle of a cylindrical mesh after the uniform smoothing.

```
block 1 11;1 11;1 6 11;
            0 1 0 1 -1 0 1
pb 1 2 1 1 2 3 xy 0 0
pb 2 2 1 2 2 3 x 0
sd 1 cy 0 0 0 0 0 1 1
sfi -2;;;sd 1
unifm 1 1 1 2 2 3 100 0 1 ;
```

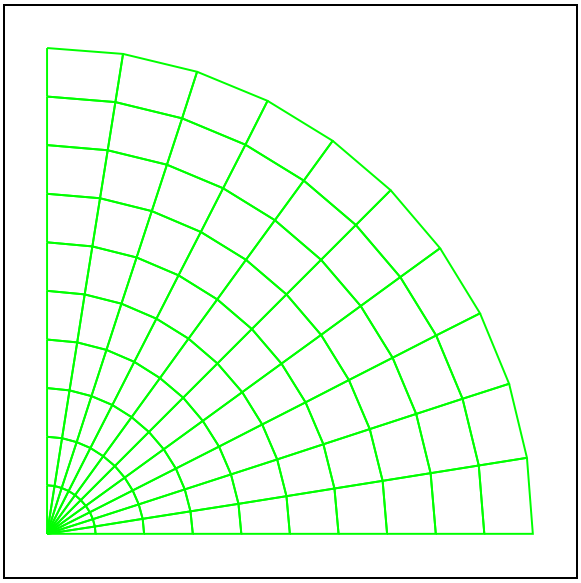


Figure 285 Uniform smoothing

In the following example, different methods are used to interpolate a symmetric mesh where 5 blocks meet at a vertex. This demonstrates one of the subtle differences in the different methods. The **bb** command is needed to glue them together. With five blocks, the center node acts like a convex boundary condition. The first picture below has no smoothing. The edges of the center elements are measured in each example for comparison purposes. Also compare the subtle differences near the concave boundaries.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

center edge length = 0.097988911

```
sd 1 sp 0 0 0 4 parameter r [sqrt(3)];
block 1 11 0 12 22 0 23 33;1  11 0 12 22;-1;
      0 0 0 0 0 0 0 0 0 0 0 0 0 4
dei 7 8; 4 5; -1;
pa 8 1 1 xy [%r*cos(36)] [%r*sin(36)]
pa 5 5 1 xy [%r*cos(108)] [%r*sin(108)]
pa 1 5 1 xy [%r*cos(180)] [%r*sin(180)]
pa 1 1 1 xy [%r*cos(252)] [%r*sin(252)]
pa 5 1 1 xy [%r*cos(324)] [%r*sin(324)]
pa 5 2 1 xy 1 0 pa 7 1 1 xy 1 0
pa 8 2 1 xy [cos(72)] [sin(72)]
pa 5 4 1 xy [cos(72)] [sin(72)]
pa 4 5 1 xy [cos(144)] [sin(144)]
pa 2 5 1 xy [cos(144)] [sin(144)]
pa 1 4 1 xy [cos(216)] [sin(216)]
pa 1 2 1 xy [cos(216)] [sin(216)]
pa 2 1 1 xy [cos(288)] [sin(288)]
pa 4 1 1 xy [cos(288)] [sin(288)]
sfi ;; -1; sd 1
bb 2 1 1 2 2 1 1;bb 4 1 1 4 2 1 1;
bb 4 2 1 5 2 1 2;bb 7 1 1 7 2 1 2;
bb 7 2 1 8 2 1 3;bb 4 4 1 5 4 1 3;
bb 4 4 1 4 5 1 4;bb 2 4 1 2 5 1 4;
bb 1 4 1 2 4 1 5;bb 1 2 1 2 2 1 5;
```

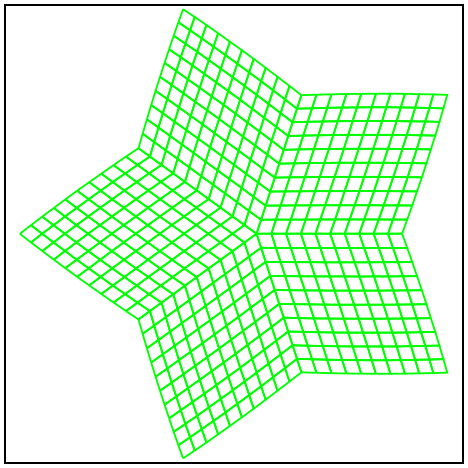


Figure 286 No smoothing

```
relax 1 4 1 2 5 1 &
      1 1 1 2 2 1 &
      4 4 1 5 5 1 &
      4 1 1 5 2 1 &
      7 1 1 8 2 1
      200 0.0001 1
```

Notice the mesh lines pull away from the center. This behavior is similar to the way relax behaves near a convex boundary.

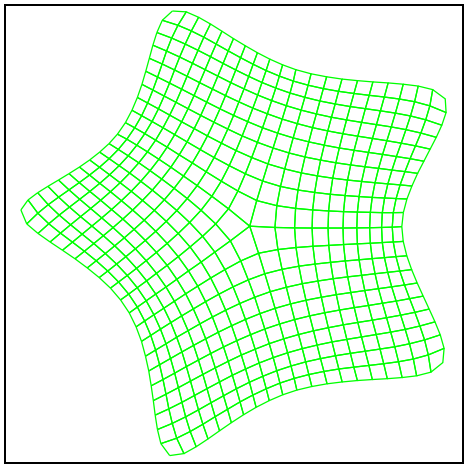


Figure 287 Relax smoothing

center edge length = 0.16685584

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

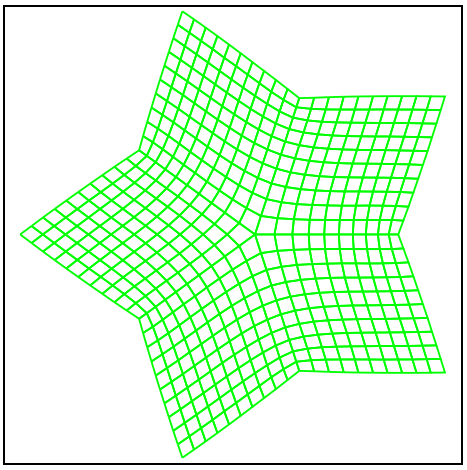


Figure 288 5 Uniform smoothing

```
unifm 1 1 1 2 2 3 &
      4 1 1 5 2 3 &
      7 1 1 8 2 3 &
      1 4 1 2 5 3 &
      4 4 1 5 5 3
      200 .00001 1
```

This method is easy to use and produces more uniform elements than relax.

center edge length = 0.13254464

```
esm 1 1 1 2 2 3 &
    4 1 1 5 2 3 &
    7 1 1 8 2 3 &
    1 4 1 2 5 3 &
    4 4 1 5 5 3
    200 .00001 1 .36 5
```

The parameters controlling the nodal distribution from the center vertex were carefully chosen so that the length of the center element is

center edge length = 0.11264142

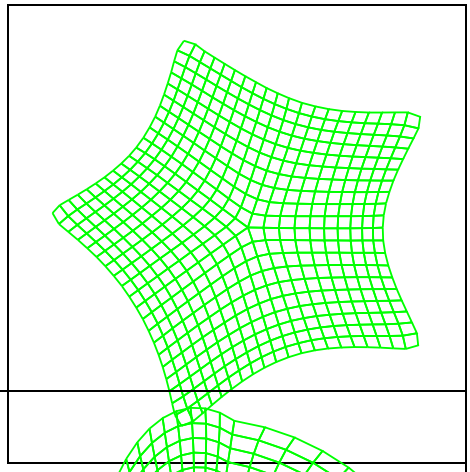


Figure 289 Elliptic smoothing

This next example shows the interior of a 7 block spherical mesh. The maximum angle in this mesh is 120.07 degrees.

```
parameters size 10 ninit 200;
sd 1 sp 0 0 0 3
partmode i
block %size %size %size;
      %size %size %size;
      %size %size %size;
      -1 -1 1 1
      -1 -1 1 1
      -1 -1 1 1
dei 1 2 0 3 4; 1 2 0 3 4;;
dei 1 2 0 3 4;; 1 2 0 3 4;
```

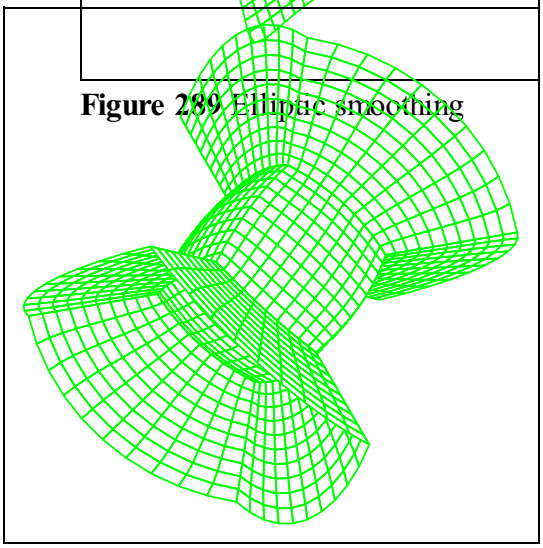


Figure 290 Inner faces of a spherical mesh

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
dei ; 1 2 0 3 4; 1 2 0 3 4;
sfi -1 -4; -1 -4; -1 -4;sd 1
bb 1 2 2 2 2 3 1;bb 2 1 2 2 2 3  1;
bb 3 1 2 3 2 3 2;bb 3 2 2 4 2 3  2;
bb 3 3 2 4 3 3 3;bb 3 3 2 3 4 3  3;
bb 2 3 2 2 4 3 4;bb 1 3 2 2 3 3  4;
bb 1 2 3 2 3 3 5;bb 2 2 3 2 3 4  5;
bb 2 1 3 3 2 3 6;bb 2 2 3 3 2 4  6;
bb 3 2 3 4 3 3 7;bb 3 2 3 3 3 4  7;
bb 2 3 3 3 4 3 8;bb 2 3 3 3 3 4  8;
bb 1 2 2 2 3 2 9;bb 2 2 1 2 3 2  9;
bb 2 1 2 3 2 2 10;bb 2 2 1 3 2 2 10;
bb 3 2 2 4 3 2 11;bb 3 2 1 3 3 2 11;
bb 2 3 2 3 4 2 12;bb 2 3 1 3 3 2 12;
unifm 2 2 1 3 3 4 & 1 2 2 2 3 3 &
      2 1 2 3 2 3 & 3 2 2 4 3 3 &
      2 3 2 3 4 3 %ninit .0001 1 ;
```

unifmi Uniform smoothing

unifmi *progression iterations min_change weight*

where

iterations	is the maximum number of iterations to use,
min_change	is an absolute error tolerance (there will be no more iterations if, in the last iteration, no coordinate was moved by more than *min_change* in any zone)
weight	is an interpolation weight factor (the value 1.0 usually works)

Remarks

See the **unifm** command for remarks.

5. Projection

The commands in this section project a vertex, edge, or face of the mesh onto a surface. When a region of the mesh is projected to a surface, it will remain on that surface no matter what other operations are made in that region of the mesh. It is a constraint on that portion of the mesh. For example, if an edge is projected twice, once to each of two different surfaces, the edge will be placed at the intersection of the two surfaces so that both constraints are satisfied.

When importing a CAD model, sometimes each surface is carefully crafted to form a face of the mesh. The **patch** command can be used to place the edges of the face of the mesh along the edges of the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

surface and to constrain the face to the surface.

However, in most cases, it is unrealistic to expect a one-to-one correspondence between the surfaces on the geometry and the faces of a good mesh. In some cases, a face of the mesh may cover only a portion of a surface. In other cases, a face of the mesh may cross over multiple surfaces. In the first case, you move the vertices close to their final position using the **pb** command, for example, and project with the **sf** or **sfi** command. In the second case, combine the multiple surfaces into a set, using the sds option of the **sd** command, and then follow the procedure for the first case. Projecting to a set of surfaces is distinct from projecting to the intersection of several surfaces. Projecting to a set of surfaces is only one constraint. Projecting to the intersection of two surfaces requires two projection commands to two different surfaces, constituting two distinct constraints on the mesh.

It is critical to the design and creation of a quality hexahedron mesh that you have this type of flexibility. This flexibility is the motivation behind most of the mesh generation commands and the Command Hierarchy. In particular, initialization commands, such as the **pb** command, always change the position of a portion of the mesh before the constraints (projections) to surfaces are calculated. The order that initialization and constraint commands are issued is ignored when the mesh is calculated. Initialization commands are executed first, then the constraints are enforced.

You can take advantage of this internal re-ordering of the commands by first projecting a face of the mesh to a surface. After inspecting the results, you can re-position a portion of the mesh with the mouse or menus. It will be as if you had moved that portion of the mesh into position and then projected to the surface.

sf project a region onto a surface

sf *region surface_type surface_parameters*

where *surface_type* and *surface_parameters* can be:

sd *sd*	for a numbered or named surface definition (**sd** command)
sds *sd1 sd2 ... sdn ;*	to combine several numbered surfaces into one
cn2p $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ t_1\ r_2\ t_2$	for a conical surface
cone $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r\ \theta$	for a conical surface
cy $x_0\ y_0\ z_0\ x_n\ y_n\ z_n$ *radius*	for a cylindrical surface
er $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ r_2$	for an ellipse revolved about an axis
iplan *a b c d*	for a plane defined by an implicit function
plan $x_0\ y_0\ z_0\ x_n\ y_n\ z_n$	for a planar surface
pl3 *system* $x_1\ y_1\ z_1$ *system* $x_2\ y_2\ z_2$ *system* $x_3\ y_3\ z_3$	for a planar surface
pr $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ t_1\ r_2\ t_2\ r_3\ t_3$	for a parabola revolved about an axis
sp $x_0\ y_0\ z_0$ *radius*	for a spherical surface
ts $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ t\ r_2$	for a torus

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

crx *line_#*	for a planar curve rotated about the x-axis
cry *line_#*	for a planar curve rotated about the y-axis
crz *line_#*	for a planar curve rotated about the z-axis
cr x_0 y_0 z_0 x_n y_n z_n *line_#*	for a planar curve rotated about arbitrary axis
cp *line_# transform ;*	for a planar curve extended in the third dimension, then transformed

Remarks

The most common way to use this command is with the sd option. This requires that the surface first be defined with the **sd** command or imported from a CAD system using the **iges** command.

This command projects a portion of the mesh onto a surface. This is the primary method for deforming the block mesh into the desired shape. Typically, the surface is defined with the **sd** command first. This way it can be drawn in the picture. Then the sd option of the **sf** command is used to project a face of the mesh to the surface. The other options in the **sf** command are available in order to retain compatibility with INGRID.

As with all mesh generation commands, they are entered into the table of commands to be executed to form the mesh. However, to actually see the results, you must request a new picture. This is an optimization feature that allows you to stack numerous commands before getting a picture of the mesh.

If you use more than one **sf** command to specify that one region be projected to more than one surface, then the multiple surfaces are interpreted in the "and" sense: that you want the region to be projected to the intersection of all the surfaces. But if you specify more than one surface with a single **sf** command, as with the **sds** surface type[5], then the multiple surfaces are interpreted in the "or" sense: that you want the region to be projected to the nearest of the surfaces.

This command is applied to the nodes that form the vertices, edges, and faces of a region, in that order. The initial or interpolated coordinates of each node are used to project it onto the specified surface.

Projection Algorithm

The simplest case is when a node is required to be on one surface. The initial or interpolated coordinates of the node is used to locate the point on the surface which is closest to it. We call this point the projection onto the surface. Note that if our projection point is an interior point of the surface and if the surface is smooth, then our projection is the classical definition of a normal projection. The

[5]The **sds** surface type is not directly available in **sf**, but you can use it indirectly. Define a numbered surface by **sd** # **sds**... and then use the surface in **sf**: **sf** *region* **sd** # .

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

tangent plane at this point is the plan that intersects the surface at this point of projection with the same normal as the surface of projection.

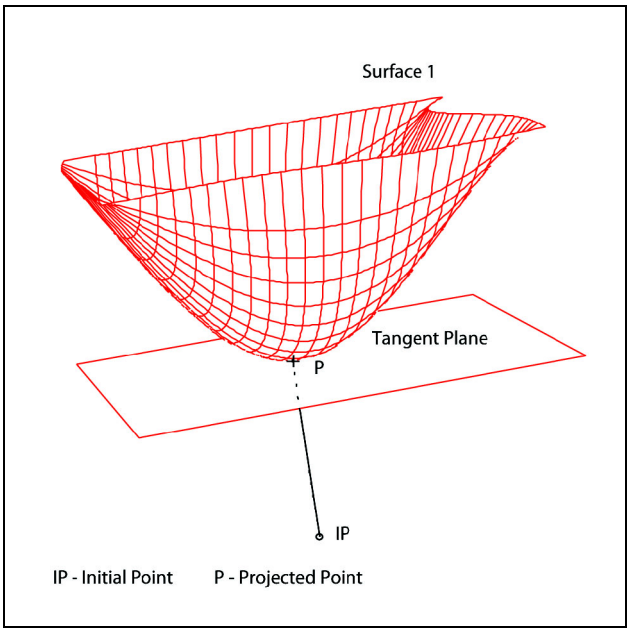


Figure 291 Projection onto Smooth Surface

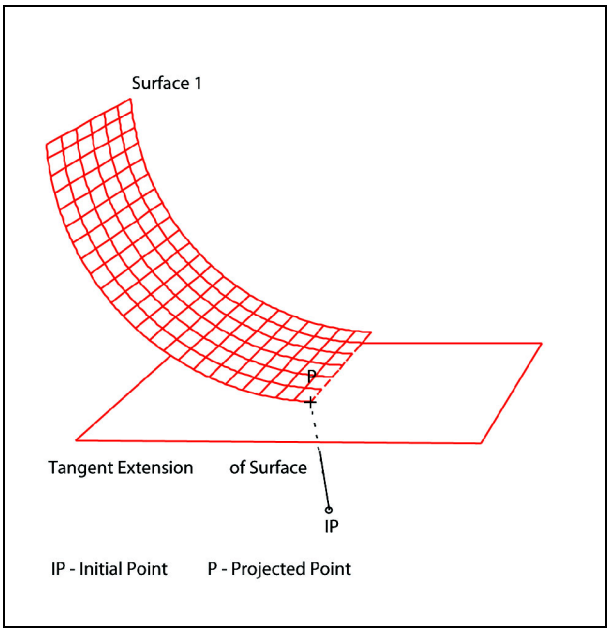


Figure 292 Projection onto Smooth Surface

But there are many situations where the projection cannot be normal. The surface may not be smooth; a common example is the surface made by rotating a polygonal line about an axis. This is not smooth at its knot points. A vertex's projection also may not be normal when the closest point of the surface is an edge of the surface.

There are situations where it is not possible to define the projection of a point onto a surface. For example, there is no well-defined way to project the center of a sphere onto the sphere. In such situations, **True*Grid*®** will print a warning message and do nothing.

In other cases, a vertex or edge may be projected to the intersection of two surfaces (**Figure 293**). A node is moved to the intersection of two surfaces using a Newton iterative method. In each iteration, the node is moved toward the intersection of the surfaces. This is done by finding the point of projection to each of the two

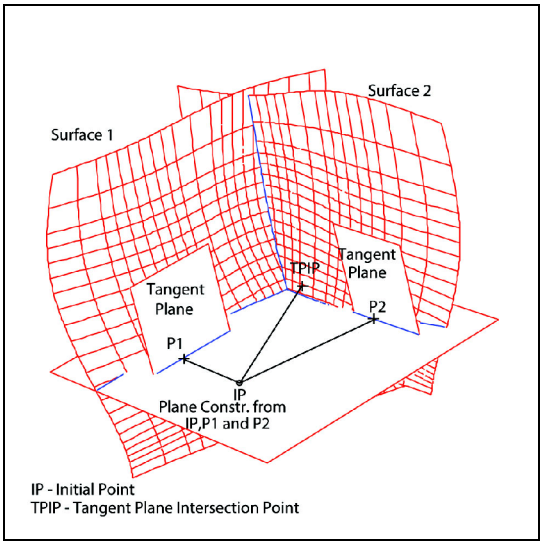


Figure 293 Projection onto 2 Surfaces

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

surfaces. The two tangent planes are intersected with the plane that passes through the original position of the node and the two points of projection. The intersection of these three planes is the approximate point of intersection of the two surfaces. After moving the node toward this approximate point of intersection, the process is repeated. In the special case, when two tangent planes are nearly tangent to each other, an alternative method is used. The intersection of tangent surfaces should be avoided because this alternative method is very slow to converge.

A similar scheme is used to project a vertex to the intersection of three surfaces. The intersection of the three tangent planes is used as the approximate point of intersection.

If a node is projected to more than three different surfaces, then it will be moved to some average or midpoint.

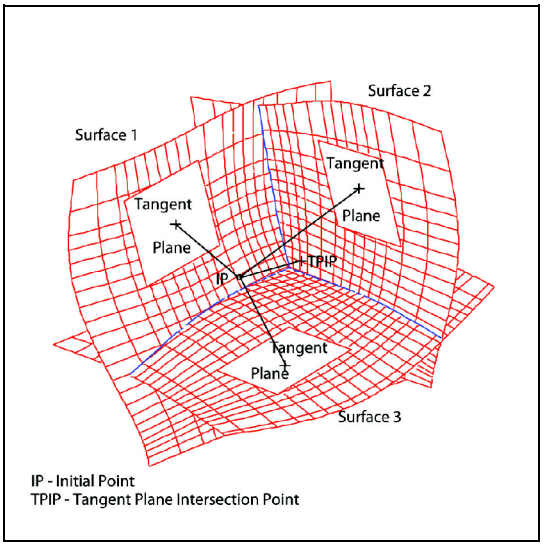


Figure 294 Projection onto 3 Surfaces

Edge nodes are give special consideration if they are not attached to a 3D curve or a surface edge. These nodes have an added constraint, depending on the nodal distribution or spacing rule to be applied to that edge (see the **res**, **drs**, **as**, **das**, and **nds** commands). The default is for nodes to be equally distributed along the edge. When an edge is projected to a single surface and the curvature along the surface is not large, then a plane is constructed through the edge's two end points which is approximately orthogonal to the surface. Then the edge nodes are distributed along the intersection of the surface and this cutting plane so as to satisfy the nodal distribution or spacing rule.

sfi project regions onto a surface by index progression

sfi *progression surface_type surface_parameters*

where *surface_type* and *surface_parameters* can be:

sd *sd*	for a numbered surface definition (**sd** command)
sds *sd1 sd2 ... sdn ;*	to combine several numbered surfaces into one
cn2p $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ t_1\ r_2\ t_2$	for a conical surface
cone $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r\ \theta$	for a conical surface
cy $x_0\ y_0\ z_0\ x_n\ y_n\ z_n$ *radius*	for a cylindrical surface
er $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ r_2$	for an ellipse revolved about an axis
iplan *a b c d*	for a plane defined by an implicit function
plan $x_0\ y_0\ z_0\ x_n\ y_n\ z_n$	for a planar surface

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

pr $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ t_1\ r_2\ t_2\ r_3\ t_3$ for a parabola revolved about an axis
sp $x_0\ y_0\ z_0$ *radius* for a spherical surface
ts $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ t\ r_2$ for a torus
crx *line_#* for a planar curve rotated about x-axis
cry *line_#* for a planar curve rotated about y-axis
crz *line_#* for a planar curve rotated about z-axis
cr $x_0\ y_0\ z_0\ x_n\ y_n\ z_n$ *line_#* for a planar curve rotated about arbitrary axis
cp *line_# transform ;* for a planar curve extended in the third dimension, then transformed

Remarks

For more details and a full discussion of this command, see the **sf** command.

spp spherical projection

spp *region direction* $x_0\ y_0\ z_0$ *id*

where the *direction* can be

i	each i-face of the region is a projection of the template
j	each j-face of the region is a projection of the template
k	each k-face of the region is a projection of the template
id	each i-face of the region is a projection of the template
jd	each j-face of the region is a projection of the template
kd	each k-face of the region is a projection of the template

where the source of projections (for directions **i**, **j**, or **k**) is at the point or the direction of projections (for directions **id**, **jd**, or **kd**) is a vector defined by

x_0	x-component of projection
y_0	y-component of projection
z_0	y-component of projection

where *id* refers to a template defined using the **tmplt** command.

Remarks

A template (see the **tmplt** command) must be defined before using this command. It is required that the template and the mesh being projected have the same number of nodes along each corresponding edge so that there is a one-to-one mapping between template and mesh.

An i-face is a face where the i-index is constant. A j-face and a k-face are similar. An i, j, or k-face can be projected to a surface and constrained by this command. Nodes of the face are placed on any

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

projected surface and on the ray which passes through the corresponding node on the template. If the **i**, **j**, or **k** direction was chosen, then the ray originates at the specified center point. If the **id**, **jd**, or **kd** direction was chosen, then the ray direction is specified.

Care must be taken to ensure that each ray radiating out through the template mesh actually intersects the surfaces of projection. If this does not occur, there will be warning messages that surfaces could not be intersected. These warnings may seen cryptic but reflect the technique used to intersect a ray with a surface.

There is no direct way to see the template, since it is from a previous part. One trick is to create a **bb** of the template and display the **bb**.

Algorithm

The algorithm to intersect the ray with a surface is done by forming two planes that intersect along the ray and then intersecting these two planes with the surface using the standard algorithm to intersect three surfaces. All of the strengths and weaknesses of the projection method will be found in this feature.

The minimum face (i, j, or k) is used to determine the mapping between the template and the mesh being aligned with the template. This is like the block boundary interface (the **bb** command) in that there are 8 ways that one face can logically be mapped to another. The one that causes the least change from the initial position of the 4 corners is the one that is chosen. If the mapping is automatically done incorrectly, simple improve the initial coordinates of the corner vertices of the minimum face of the mesh so that the choice is obvious.

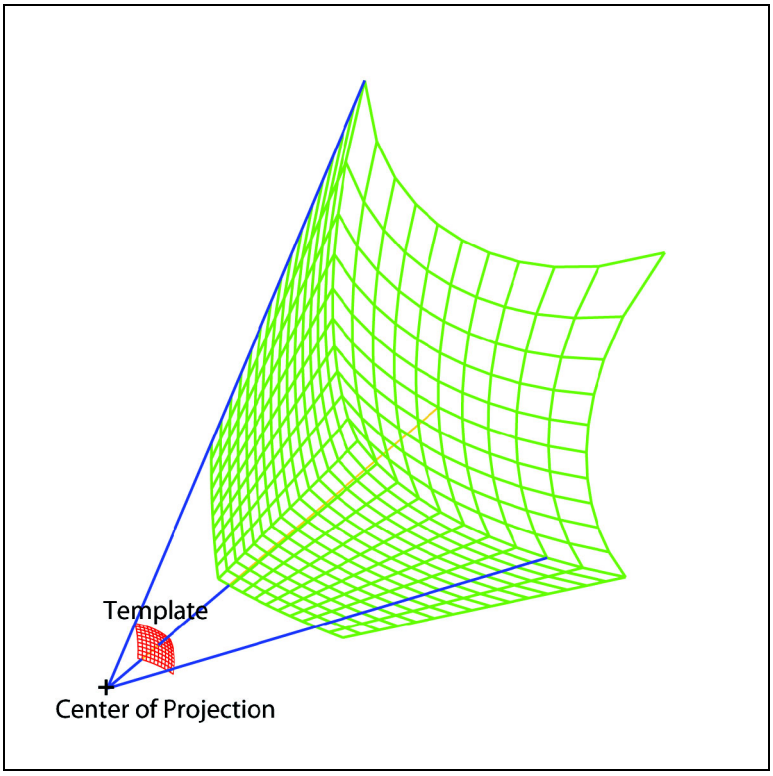


Figure 295 Rays of spherical projection

Example

```
sd 1 sp 0 0 0 1
sd 2 sp 5 0 10 8
sd 3 sp 5 0 10 5
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
block 1 11;1 11;-1;
      -.3 .3 -.3 .3 1
sfi ;; -1; sd 1
tr 1 1 1 2 2 1 ry 30;
tfi ;;-1;
tmplt 1 1 1 2 2 1 1
mate 0
endpart
block 1 11;1 11;1 16;-3 3 -3 3 3 6
tr 1 1 1 2 2 2 ry 30;
sfi ;; -2;sd 3
sfi ;; -1;sd 2
spp 1 1 1 2 2 2 k 0 0 0 1
```

tmplt create template used by spp

tmplt *region id*

where *id* is an integer identifier for reference

Remarks

The typical method of constructing a template is to build a shell part, set the material to 0 so that the elements are not preserved in the data base, and issue this command. To be able to visualize the template later on, also assign a **bb** to the template face and then display the **bb**.

The template is only useful with the **spp** command in later parts.

patch attaches a face to a 4 sided surface patch

patch *region surface_#*

Remarks

A mesh face can be attached to a four-sided surface using this command. This is really a macro which attaches the four edges of a mesh face to the four sides of a surface, and projects the face to the surface. This command works only with a single four-sided surface. This command is intended for casual users of **True*Grid*®** who insist on using **True*Grid*®** the way they use other mesh generators, one surface patch at a time. This is essentially the mapped mesh method. It does not take advantage of most of the features of the projection method and is as inflexible as those who insist on using it.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Highlight a single face of the mesh with no deleted portions, select a surface, and click on the ***Attach*** button.

ms sequence of surface projections

ms *region index_direction surfaces*

where

index_direction can be **i**, **j**, or **k**, and

surfaces can be specified in one of two ways. In the first method, each surface is specified separately, first by a surface type followed by the appropriate parameters. See the Surface Dictionary for details on these surfaces and their parameterization. The surface types can be one of:

sd numbered surface definition
sp sphere
cy cylinder
plan plane
pr paraboloid (parabola revolved about an axis)
er ellipsoid (ellipse revolved about an axis)
cone cone
cn2p cone defined by 2 points
ts torus
cr planar curve rotated about an axis
crx planar curve rotated about the x-axis
cry planar curve rotated about the y-axis
crz planar curve rotated about the z-axis
cp surface formed by extending a planar curve infinitely along the third dimension
xyplan start with a xy-plane and transform it
yzplan start with a yz-plane and transform it
zxplan start with a zx-plane and transform it
sds a list of defined surfaces
xcy a cylinder in the x-direction to be transformed
ycy a cylinder in the y-direction to be transformed
zcy a cylinder in the z-direction to be transformed
pl3 a plane through 3 points
iplane plane defined by an implicit function

The second method of specifying *surfaces* is to specify a surface sequence type followed by the appropriate parameters:

ppx for parallel planes normal in the x-direction

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ppy for parallel planes normal in the y-direction
ppz for parallel planes normal in the z-direction
cnsp for concentric spheres
cncy for concentric cylinders
pon for similar planes offset normally
pox for similar planes offset in the x-direction
poy for similar planes offset in the y-direction
poz for similar planes offset in the z-direction

where the format for surface parameters depends on the surface type as follows:

ppx $x_1\ x_2$ ... where *x1*, *x2*, ... are the x-coordinates of the planes
ppy $y_1\ y_2$ ... where *y1*, *y2*, ... are the y-coordinates of the planes
ppz $z_1\ z_2$ ... where *z1*, *z2*, ... are the z-coordinates of the planes
cnsp $x_0\ y_0\ z_0\ r_1\ r_2$ ...
where (x_0,y_0,z_0) is the center of the spheres and r_1, r_2, ... are their radii
cncy $x_0\ y_0\ z_0\ x_n\ y_n\ z_n\ r_1\ r_2$ ...
where the axis of the cylinders passes through the point (x_0,y_0,z_0), parallel to the vector (x_n,y_n,z_n); and r_1, r_2, ... are their radii
pon *x0 y0 z0 xn yn zn offset_1 offset_2 ...*
pox *x0 y0 z0 xn yn zn x_offset_1 x_offset_2 ...*
poy *x0 y0 z0 xn yn zn y_offset_1 y_offset_2 ...*
poz *x0 y0 z0 xn yn zn z_offset_1 z_offset_2 ...*

Remarks

Each reduced index face of the region in the specified direction is projected onto a corresponding surface in the sequence of surfaces. This command is included for historical reasons. The preferred command is **sf** and **sfi**.

Examples

```
ms 1 1 1 4 5 6 i
cnsp 0.1 0.12 0.14 1 2 3 4
```

Four concentric spheres are used in this command. They are all centered at the point (0.1,0.12,0,14) with radii of 1, 2, 3, and 4. The first i-face in the specified region, where i is a constant 1, j ranges from 1 to 5, and k ranges from 1 to 6, is projected onto the sphere of radius 1. The second i-face, where i is a constant 2, is projected onto the sphere of radius 2. In a similar fashion, the faces where i is a constant 3 and 4 are projected onto the spheres of radius 3 and 4, respectively.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

6. Nodal Spacing Along Edges

The commands in this section allow you to control the distribution of nodes along an edge in the mesh. The nodes on the interior of a face are affected indirectly by these commands because the face nodes are interpolated, based on the nodal distributions along its 4 bounding edges. The interior nodes of a 3D block are also affected by the nodal distributions along edges, again, because the interior nodes of a 3D block are interpolated, based on the nodal distribution on its 6 bounding faces. There are many ways that the interior of a face and the interior of a 3D block can be interpolated. It is up to you to choose the appropriate nodal distribution along the edges and the appropriate interpolation. The default nodal distribution along each edge is equal spacing. The default interpolation for a face or 3D block is linear. The type of interpolation may seem to be subtle when you have small curvature and equal spacing along edges. But when things conditions are non-linear in the mesh, the type of interpolation can make a big difference in the quality of the mesh. There are commands to distribute the nodes along an edge, face or a 3D block. But when such a nodal distribution is applied to a face or a 3D block, it is only directly affecting the edges on that region and indirectly affecting the interior nodes through the interpolation of the nodes from the edges.

If an edge is assigned a nodal distribution and that edge is within the interior of a region that is interpolated, the nodal distribution will be ignored. This is because of the command hierarchy, since faces and 3D blocks are interpolated after the edge nodes are calculated. On the other hand, if you apply an iterative smoothing method such as **relax**, **tme**, or **unifm**, then the nodal distribution of the interior edge may only be slightly affected, based on the number of iterative smoothing steps that are applied.

It is possible to over-constrain the mesh by applying different nodal distributions along two multiple edges that intersect. Nodal distribution along edges are done sequentially, not as a system of constraints that require a simultaneous solution. As a consequence, only one of the intersecting multiple edges will satisfy its nodal distribution constraint.

When poorly initialized meshes are projected across multiple regions with the added constraint imposed by nodal distributions, if there is an angle along the initial composite edge smaller than 5 degrees, then that part of the edge is ignored when the nodes are distributed along the edge. It is assumed that in this case, the initial shape should not be preserved. Otherwise, the initial shape of the composite edge was preserved.

res relative spacing of nodes of an edge

res *region direction ratio*

where

direction is one of **i**, **j**, or **k**, and

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ratio is a positive number.

Remarks

This command spaces the nodes of an edge of the mesh, so that the ratios of the distances between them will be a constant. The importance of **res** arises from the fact that all interpolation, projection, and relaxation methods depend on the nodes at the boundary of the region they affect.

By default, edge nodes to are equally spaced. That is equivalent to issuing this **res** command with a *ratio* of 1.0.

The distances between adjacent nodes have a constant ratio, that is, they form a geometric progression. The distances δ_i between nodes i and i+1 obey the relation

$$\delta_{i+1}/\delta_i = ratio$$

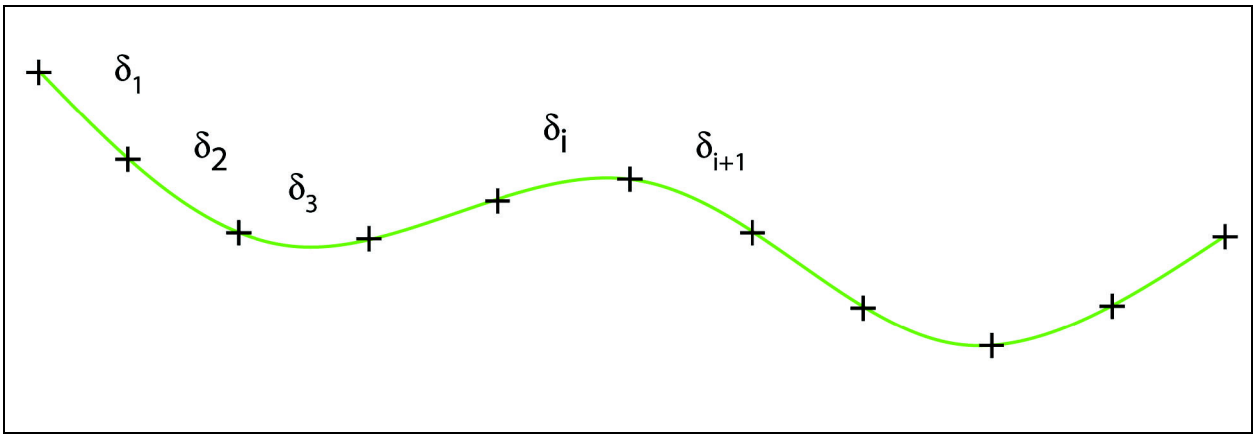


Figure 296 Nodal distribution with 1 control parameter

True*Grid*® uses this rule to assign coordinates to all edges of the mesh within the specified region and in the specified direction. For example,

```
res 1 1 1 2 2 2 i 2
```

spaces the nodes geometrically along the four edges of the region in the i-direction. More precisely, it affects the edges whose region specifications are

`1 1 1 2 1 1`, `1 2 1 2 2 1`, `1 1 2 2 1 2`, and `1 2 2 2 2 2`.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

You can position nodes of several consecutive edges as if they were one edge. The geometric zoning will be consistent across the several regions. ignoring the interior partitions. For example, if the j-edge 1 1 1 1 4 1 in reduced indices has 7 interior nodes where the first node is located at (0,0,0) and the last node is located at (0,255,0), then the command

```
res 1 1 1 1 4 1 j .5
```

will produce the following sequence of y-coordinates for the 7 interior nodes:

128, 192, 224, 240, 248, 252, and 254.

Each distance between two consecutive nodes will be half of the previous distance in the sequence.

drs relative spacing of nodes of an edge from both ends

drs *region direction ratio$_1$ ratio$_2$*

where

direction	is one of **i**, **j**, or **k**,
ratio$_1$	is a positive number, and
ratio$_2$	is a positive number.

Remarks

This should be used to distribute nodes along a single edge or to identify several edges in the same direction where the reduced index partition between the edges is to be ignored. Two ratios are specified in this command. The first ratio is the relation of the distances between nodes in the first half of the edge. If δ_i is the distance from node i to node i+1, then

$$\delta_{i+1}/\delta_i = \text{ratio}_1$$

In the second half of the edge, the second ratio is

$$\varepsilon_{j+1}/\varepsilon_j = \text{ratio}_2$$

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

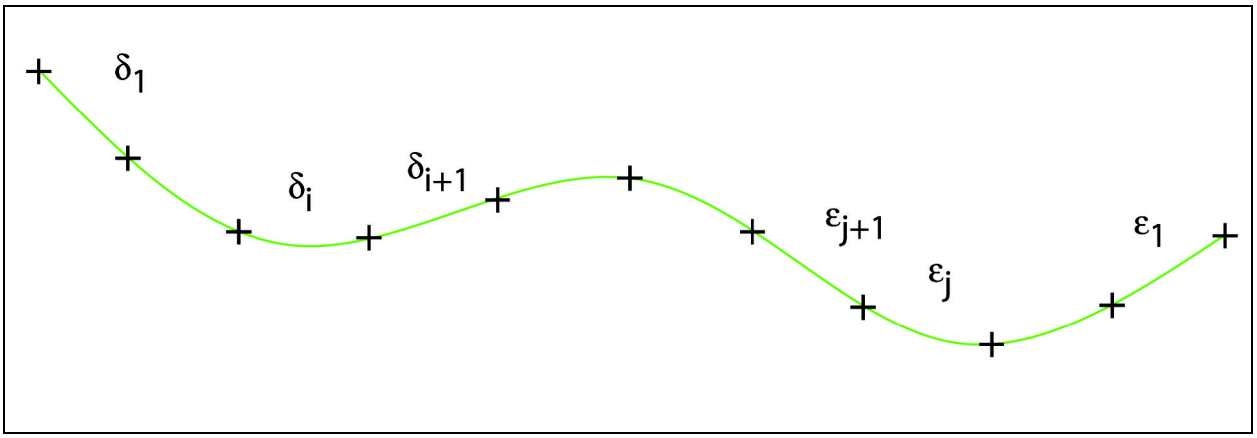


Figure 297 Nodal distribution with 2 control parameters

If there is an odd number of nodes along the edge, then the lengths of two middle intervals will be the same. It is possible to require special zoning across several regions in more than one direction at a time. It is also possible to over-specify the zoning and the results can be unsatisfactory. The transfinite interpolation over several regions usually produces the desired results by treating the zoning requirements as boundary conditions for the algebraic interpolation. See also the **as**, **das**, **res** and **nds** commands. This is used to create nodal clustering at both ends by making both ratios greater than 1.0.

as absolute spacing of first or last element of an edge

as *region direction flag size*

where

direction	is **i**, **j**, or **k**,
flag	is 0 for the first element or 1 for the last element, and
size	is the first or last element size.

Remarks

The absolute size of the first or last element is specified for nodes along an edge of the mesh. The remainder of the nodes are distributed by arc length using a derived geometric progression like **res** so that the change in size of elements along the edge is smooth.

das absolute spacing of first and last element of an edge

das *region direction* gap_1 gap_2

where

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

direction is **i**, **j**, or **k**,
gap_1 is the size of the first element, and
gap_2 is the size of the last element.

Remarks

The absolute size of the first and last element is specified for nodes along an edge of the mesh. The remainder of the nodes are distributed by arc length using a derived geometric progression like **drs** so that the change in size of elements along the edge is smooth. The sum of the gaps must be less than or equal to the total arc length of the edge.

nds generalized nodal distributed along an edge

nds *region direction density*
where
direction is **i**, **j**, or **k**, and
density is a density function number defined by **ndd**.

Remarks

This command should be used to distribute nodes along a single edge or to identify several edges in the same direction where the reduced index partition between the edges are to be ignored. The distribution is specified by using a previously defined nodal density function using the **ndd** command. In order to display a nodal density function, use the **dndd** command. It is possible to require special zoning across several regions in more than one direction at a time. It is also possible to over-specify the zoning and the results can be unsatisfactory. The transfinite interpolation over several regions usually produces the desired results by treating the zoning requirements as boundary conditions for the algebraic interpolation. See also the **as**, **das**, **res**, and **drs** commands.

ndd nodal density distribution function

ndd *density_function_# option*
where an *option* can be
ndlp x_1 z_1 x_2 z_2 ... ;

Remarks

This defines a numbered nodal distribution density function to be used by the **nds** command in the part phase. A polygonal line is used to define a density function. Nodes will be selected along a specified

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

edge using the nds command such that the density matches this function. Use the **dndd** command to show the density function and the nodal distribution. In these pictures, nodes are positioned along the curve, relative to the other nodes, so that the area below the curve and between the nodes is the same for every pair of nodes in sequence.

Examples

```
block 1 21;1 21;-1;1 2 1 2 0
ndd 1 ndlp 0 0 1 1;
ndd 2 ndlp 0 1 1 0 2 1;
ndd 3 ndlp 0 1 1 1 2 0 3 1 4 1;
ndd 4 ndlp
for idx 0 180 1
%idx [abs(cos(%idx))]
endfor
;
nds 1 2 1 2 2 1 i 1
nds 1 1 1 2 1 1 i 2
nds 1 1 1 1 2 1 j 3
nds 2 1 1 2 2 1 j 4
```

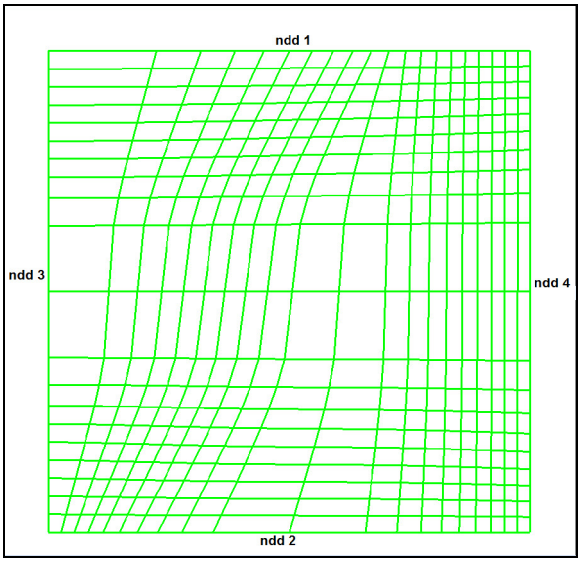


Figure 298 4 nodal density distributions

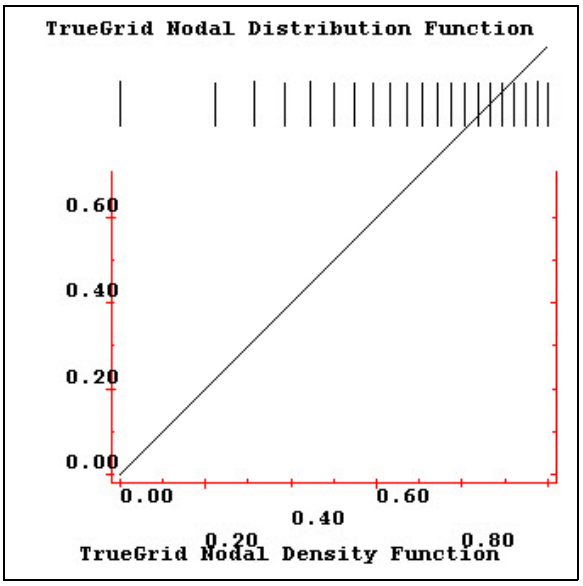


Figure 299 ndd 1

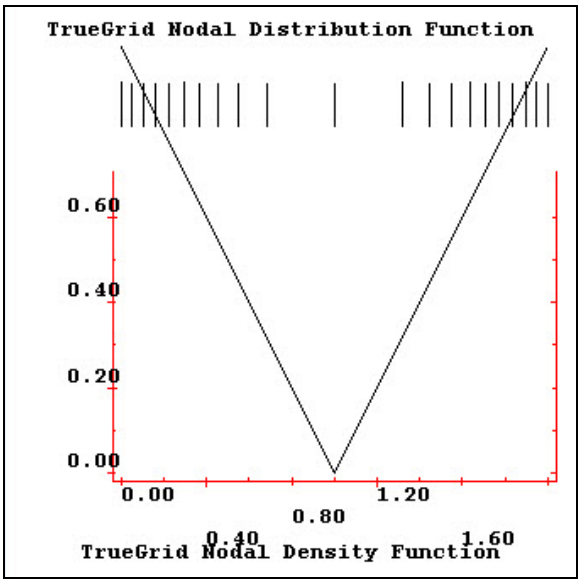


Figure 300 ndd 2

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

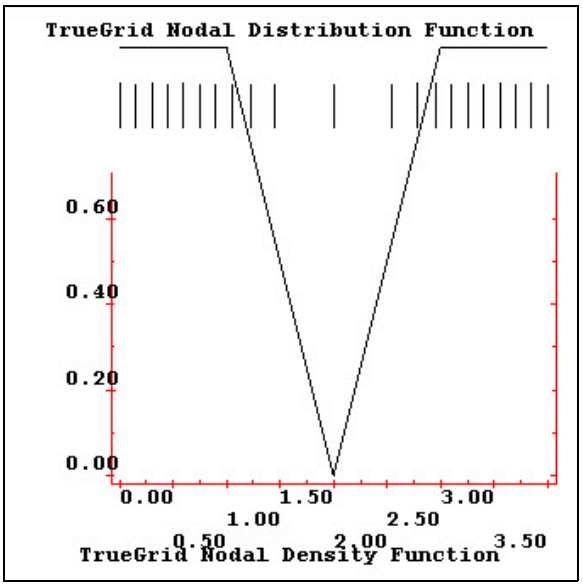


Figure 301 ndd 3

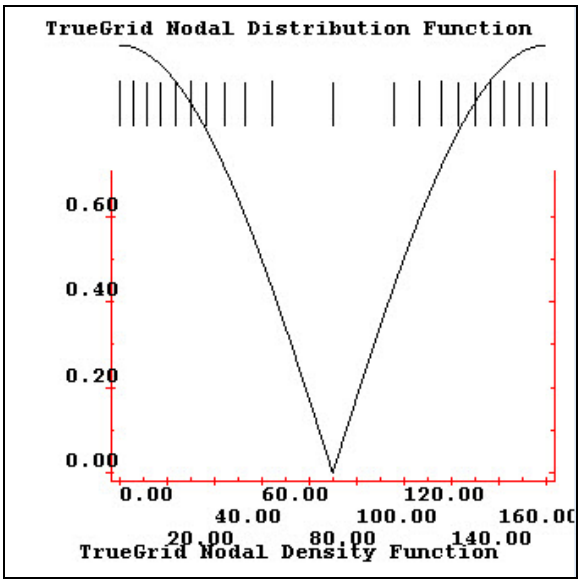


Figure 302 ndd 4

dndd display a numbered density distribution function

dndd *density_function_# #_nodes*
where *#_nodes* is the number of nodal positions in the display

Remarks

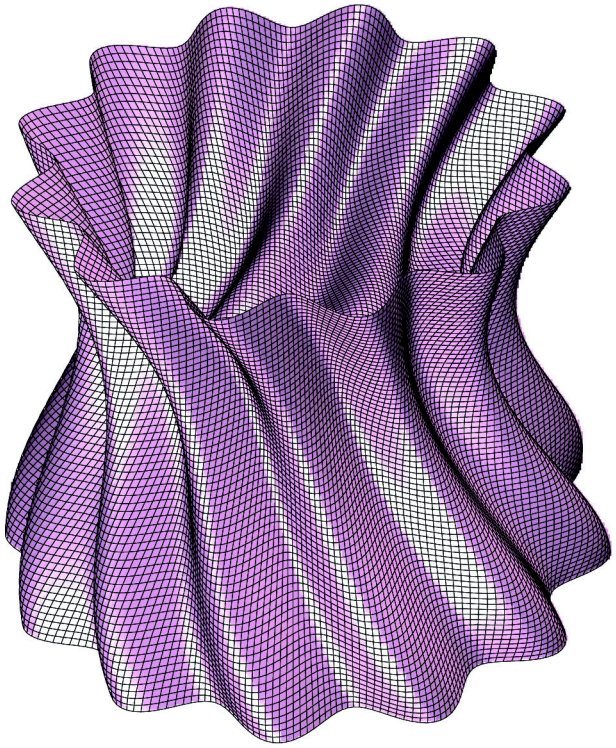
Display a nodal distribution density function by number and a sample nodal distribution. See the examples in the **nds** command for pictures produced by the **dndd** command.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

7. Equations

You can use FORTRAN-like equations to directly specify or modify the coordinates of nodes in a region of the mesh. There are two keys to using these features. First, equations are applied to the mesh after everything has been initialized, interpolated, and projected. This cannot be changed by changing the order of the commands. Within the group of equations which you may issue, the order is significant. Secondly, all calculations are done in the coordinate system of the part being generated. This means that if the part was initialized using the cylinder command, then the coordinates x, y, and z are the polar coordinates. For example:

```
cylinder -1;1 291;1 71;1 0 360 0 2
x=x+.1*cos(12*y+z*240)+.2*cos(4*k)
```



Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

dom specify the region applied to x=, y=, z=, t1=, t2=, and t3=

dom *region*

Remarks

This sets the reduced index region used by the commands **x=**, **y=**, **z=**, **t1=**, **t2=**, and **t3=** when assigning the coordinates x, y, z, and the temporary variables t1, t2, and t3. This region is initially set to the entire part.

When an equation is used to generate coordinates, the equation is evaluated for each node within the specified region. If a node has been deleted from the mesh, then the equation is not evaluated for that node and no assignment is made.

Examples

```
dom 1 1 1 2 2 2
x = 2*x
```

The x-coordinates are doubled in the region with reduced indices ranging in the i-, j-, and k-direction from 1 to 2.

x= assign x-coordinates by evaluating a function

x = *fortran_expression*
where
fortran_expression is an algebraic expression

Remarks

This command evaluates a FORTRAN-like expression and assign the result to the x-coordinate for each node in the specified region (see the **dom** command). These remarks apply to all the commands **x**, **y**, **z**, **t1**, **t2**, and **t3**. Spaces before or after the "=" sign are optional.

These commands are applied in a region specified by the last **dom** command. If no **dom** command has been issued, they are applied to the entire part.

Equations are evaluated after initialization, interpolation, projection, and smoothing of the mesh. Equations are the last functions executed in the Command Hierarchy.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

X, y, and z are interpreted within the part's coordinate system. In cylindrical coordinates, x, y, and z are the radius, angle (θ), and axial distance, respectively.

The rest of these remarks describe the rules for the algebraic equation.

For each node in the specified region, the variables **i**, **j**, and **k** are assigned the node's indices. Any reference in the equation to the variables **x**, **y**, **z**, **t1**, **t2**, or **t3** refers to the value of the corresponding 3 dimensional arrays with the indices **i**, **j**, and **k**. If one of these variables is on the left side of an = sign, its value will be changed, just as in FORTRAN.

For quadratic elements, the neighboring quadratic nodes (i.e. those mid-edge nodes belonging to the elements that are next to the boundary, but just outside the domain, of the region being modified by the FORTRAN equation) will also be modified to maintain a smooth mesh.

The operands in the equation can be the coordinates **x**, **y**, or **z**, the temporary variables **t1**, **t2**, or **t3**, the node indices **i**, **j** and **k**, integers and floating point numbers, and parameters.

The operators are +, -, *, /, and either ** or ^ for exponentiation.

Parentheses can be arbitrarily embedded.

These FORTRAN-like algebraic equations support the following functions:

int(a) : truncate a number
nint(a) : round off a number
abs(a) : absolute value
mod(a1,a2) : a1 modulo a2
sign(a1,a2) : sign of a2 to the absolute value of a1
max(a1,...,an) : choose the maximum from a list
min(a1,...,an) : choose the minimum from a list
sqrt(a) : square root
exp(a) : e to the power of a
log(a) : natural logrithm
log10(a) : logrithm base 10
sin(a) : trigometric sine where a is in degrees
cos(a) : trigometric cosine where a is in degrees
tan(a) : trigometric tangent where a is in degrees
asin(a) : trigometric arc sine in degrees
acos(a) : trigometric arc cosine in degrees
atan(a) : trigometric arc tangent in degrees
atan2(a1,a1) : trigometric arc tangent in degrees with

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

both coordinates
sinh(a) : hyperbolic sine where a is in degrees
cosh(a) : hyperbolic cosine where a is in degrees
tanh(a) : hyperbolic tangent where a is in degrees

Two additional random number functions are available. Each has several optional arguments. They are

norm([seed[,mean[,sig]]]) : normal distribution
rand([seed[,mean]]) : uniform distribution with a range of 1.0

The seed initializes the random number generator once for each equation. It defaults to 0.0, which has a different meaning on different systems. The mean can also be set or it defaults to 0.0. The standard deviation defaults to 1.0.

All calculations are done in floating point.

The angular arguments or values of the functions sin, cos, tan, asin, atan, and atan2 are in degrees.

Operands for /, **, and ^ and the arguments for mod, sqrt, exp, log, log10, asin, and acos are verified before the function is invoked.

An expression is limited to 240 operators, operands, function calls, and parentheses.

To add a comment, use a dollar sign followed by a space ("$ "). **True*Grid*®** will treat the rest of the line as a comment.

To extend an equation across several lines, use the ampersand character ("&") as the last character of the line.

To put several equations in one line, use semicolons (";"). A semicolon terminates an equation and begins a new one, as if each equation were entered on its own line. If there is no semicolon or ampersand, **True*Grid*®** assumes that each line contains exactly one equation.

Examples

```
x = x + 1.0              $ translate the part in the x-direction
t1 = x
x = y
y = t1                   $ swap the x- and y-coordinates
x=i*i;y=j*j;z=k*k;       $ each coordinate is its squared index
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
t1 = sqrt(x*x+y*y)        $ radial polar coordinate
t2 = atan2(x,y)           $ angular polar coordinate
t2 = t2 + 0.1 * k         $ increasing the polar angle
x  = t1 * cos(t2)         $ convert back to Cartesian
y  = t1 * sin(t2)         $ ditto
```

The result of this fourth example is to put a twist into the mesh as the index k increases.

y= assign y-coordinates by evaluating a function

y = *fortran_expression*
where
fortran_expression is an algebraic expression.

Remarks

This command evaluates a FORTRAN-like expression and assign the result to the y-coordinate for each node in the specified region (see the **dom** command). See the discussion of **x=** on the preceding pages.

z= assign z-coordinates by evaluating a function

z = *fortran_expression*
where
fortran_expression is an algebraic expression

Remarks

Evaluates a FORTRAN-like expression and assign the result to the z-coordinate for each node in the specified region (see the **dom** command). See the discussion of **x=** on the preceding pages.

t1= assign a temporary mesh variable by evaluating a function

t1 = *fortran_expression*
where
fortran_expression is an algebraic expression

Remarks

Evaluates a FORTRAN-like expression and assigns the result to a temporary variable for each node

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

in the specified region (see the **dom** command).

t2= assign a temporary mesh variable by evaluating a function

t2 = *fortran_expression*
where
fortran_expression is an algebraic expression

Remarks

Evaluates a FORTRAN-like expression and assigns the result to a temporary variable for each node in the specified region (see the **dom** command).

t3= assign a temporary mesh variable by evaluating a function

t3 = *fortran_expression*
where
fortran_expression is an algebraic expression

Remarks

Evaluates a FORTRAN-like expression and assigns the result to a temporary variable for each node in the specified region (see the **dom** command).

8. Edit Commands

True*Grid*®'s Command Hierarchy requires that it keep track of all the meshing commands that you have issued for the present part. This is done by means of a table of all of the commands issued. You have access to and can modify this table of commands. You can highlight a region by selecting a command from this table. You can deactivate any of these commands or reactivate them. You can select a region in the mesh and see only those commands related to the region. You can recover the command dialogue box so that you can modify the command an re-issue it. These features are useful in debugging the mesh.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

history show the history table

history *(no arguments)*

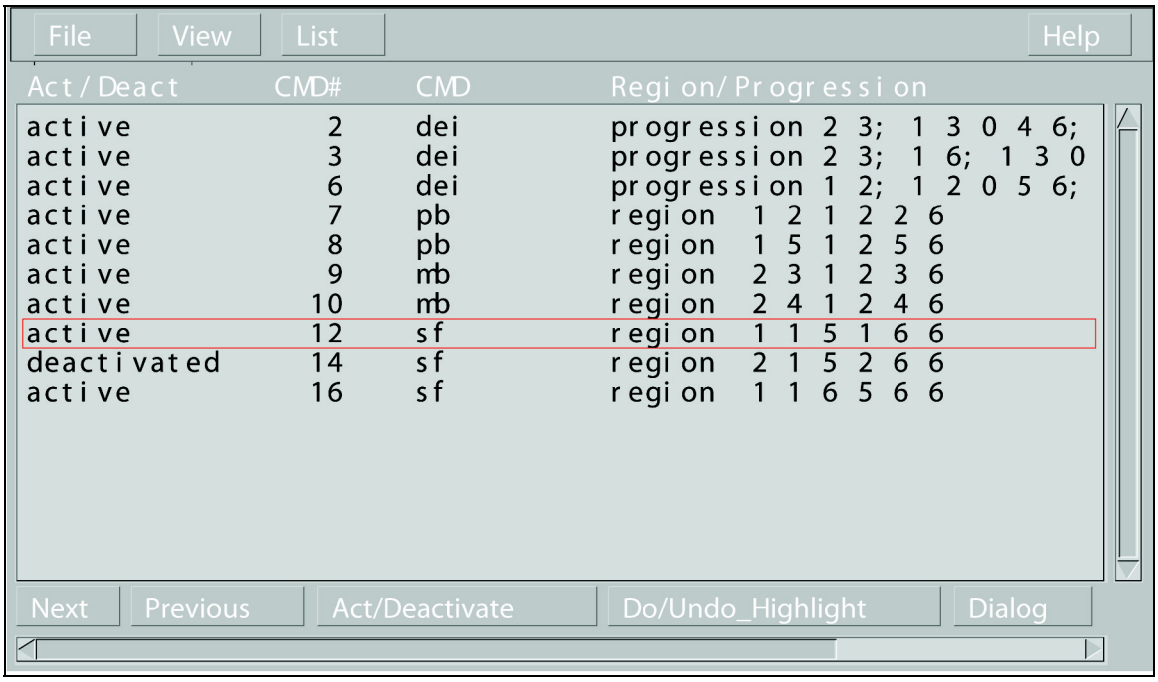


Figure 304 History window with commands associated with part of the mesh

Remarks

The primary function of the history window is to debug the mesh. Most users make mistakes occasionally by requiring a portion of the mesh to be in two or more places at the same time. Sometimes this can be difficult to detect. This history table can make the detection quite easy. There are several features in the history window that aid in this debugging of a mesh. Click on the problem region and issue the **history** command, click on the ***History*** button in the environment window, or type the **F3** function key. Then deactivate or reactivate commands one at a time until you discover the problem. There is an art to this and you cannot be effective unless you have a good understanding of the Command Hierarchy.

The history window contains previously issued meshing commands, listed in the order that they were issued. As you issue commands, they are added to the history window. If you first select a region in the mesh within the computational window, then the history window will only contain those commands whose scope includes the region you have selected. This window serves many purposes, making it easy to review the commands issued thus far in the development of the part.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

A selected command is shown with a red box around it and this can be done in two ways. Click the left mouse button on the command or click the ***Next*** or ***Previous*** button to get to the neighboring command.

It is easy to determine the regions within the part that are associated with a command in the history window. Select the command in question and click on the ***Do/Undo_Highlight*** button. Alternatively, position the mouse near the region or index progression of a command and click the middle mouse button (the right mouse button for a two-button mouse). Instantly the index bars in the computational graphics window are changed to reflect the regions chosen for the command selected from the history window. The corresponding regions in both the computational and physical graphics window are highlighted. This region selection can then be modified and captured into either a dialogue box or in the text window.

The dialogue box that was used to issue a command can be recovered using the history window. Click on the ***Dialog*** button. Alternatively, position the mouse near the command name and click the middle mouse button (the right mouse button for a two-button mouse). The dialogue box will appear. This can be repeated without quitting the previous dialogue box.

The active and deactivated commands are identified in the history window. To deactivate a command in the history window, click on the ***Act/Deactivate*** button. Alternatively, move the mouse to the word *active* associated with the command which is to be deactivated and click the middle button (right button for a two-button mouse). The **decmd** command to deactivate this command is automatically issued and recorded in the session (tsave) file. Note that the mesh is not automatically changed in the picture. You must issue a graphics command before **True*Grid*®** builds a new mesh reflecting the deactivation of the command.

These last two features can be used together to effectively modify a mesh command. First, deactivate the command. Then use the ***dialog*** button to create a dialogue box with all of its arguments specified. Modify some of the arguments and re-issue the command by clicking on the ***EXEC/QUIT*** button.

In a similar fashion, the deactivated command can be re-activated. Then the associated **actcmd** command is automatically issued and recorded in the session (tsave) file. The combination of these features can be very useful when examining an unfamiliar command input file. Insert the **interrupt** command into this file where you wish to investigate. Then run **True*Grid*®** with this command file. When it becomes interactive at the **interrupt**, use the history window to investigate the different regions of the part.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The ***View*** menu is used to control the content and format of the information in the history window. The ***Display Item*** submenu lists the items displayed for each command. The selection is made by toggling the check mark on the left on or off for that item. The ***Act/Deact*** column indicates if a command is active or inactive. The ***CMD#*** is the internal reference number of the command. The first command of a part is the part command that started the part. It does not appear in this window. The smallest sequence number to appear in the window is 2. ***CMD*** refers to the command name. The ***Description*** item is a short phrase about the command. The ***Region/Progression*** item identifies the part of the mesh affected by the command and this is known as the scope of the command. ***Arguments*** of the commands can be shown. Since this list of items per command can be long, a scroll bar is provided to view everything.

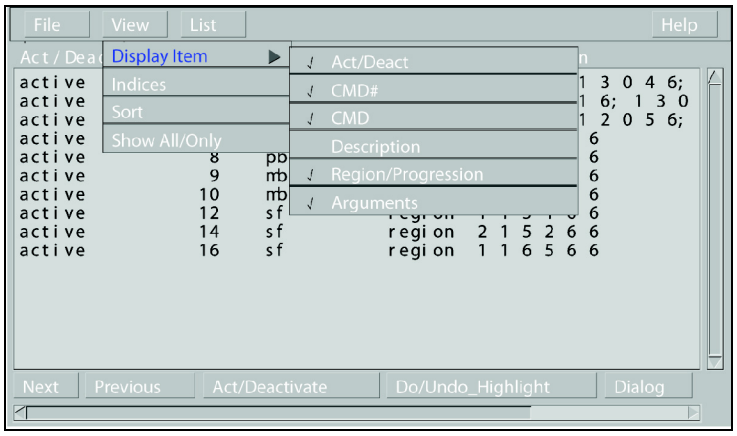


Figure 305 Selecting items in the history window

The ***Indices*** menu makes it possible to toggle between ***Full Indices*** and ***Reduced Indices***. This applies to commands which require a region or an index progression.

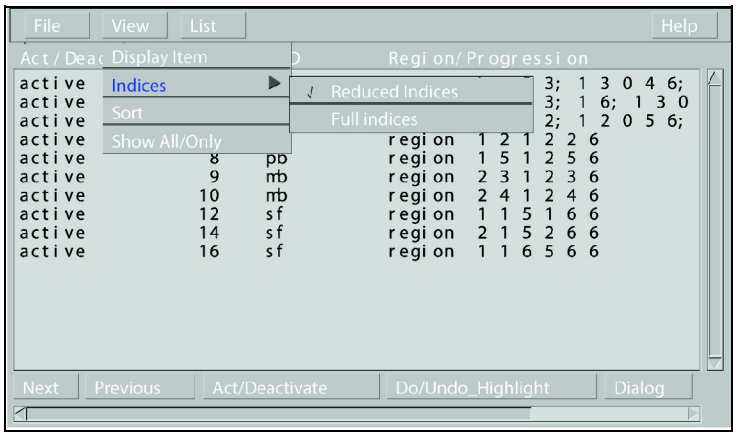


Figure 306 Choosing full or reduced indices

The ***Sort*** submenu can be used to change the order of the commands found in the history window. Only one choice can be made at a time. The check mark indicates the one presently in effect. ***by Sequence*** means that the commands are order by their sequence number (i.e. the order they are issued). If the by Command Hierarchy is selected, then the

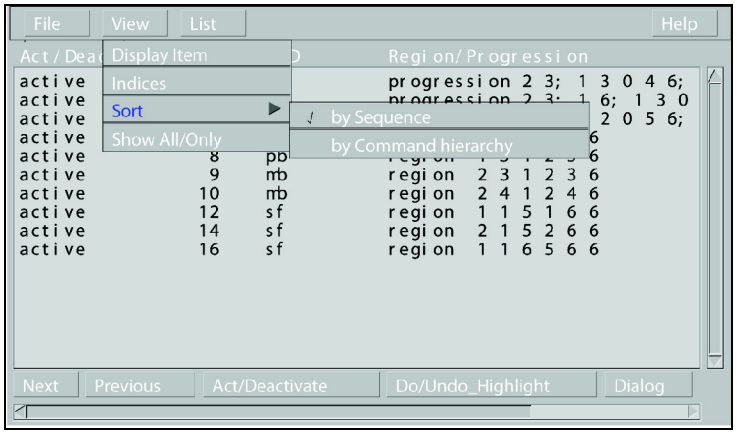


Figure 307 Selecting the order of the commands

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

commands are ordered the way they are executed.

The ***Show All/Only*** menu controls which commands are selected for the history window. ***Show Related Commands Only*** is the default. It means that only commands that apply to or whose scope include the highlighted regions will be placed in the window. This applies only at the time the window is created. If you wish to change the scope of the window to a new region, select the new region and then select the Show Related Commands Only option. Alternatively, kill the history window and start a new one. Only one history window is allowed at a time. If ***Show All Commands*** is selected, then all of the commands will be listed in the history window.

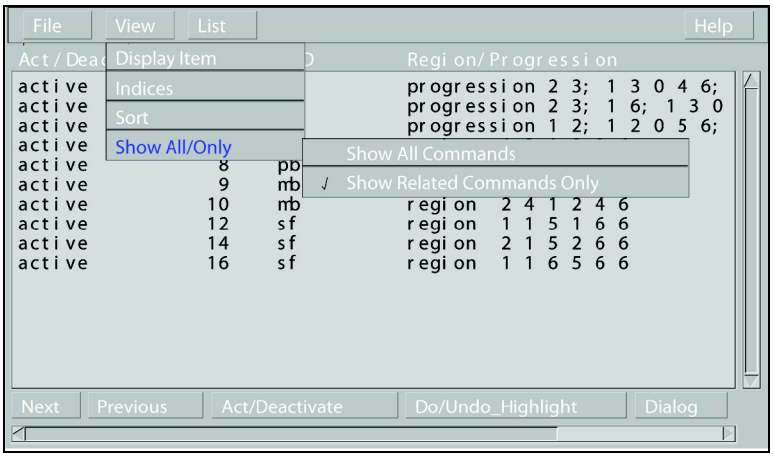


Figure 308 Selecting scope of commands

The ***List*** button will create a window with a list of objects used in the scope of the commands found in the history window. One can choose ***Surface***, ***Curve***, ***Edge***, and ***Block Boundary***. These lists are maintained as new commands are added.

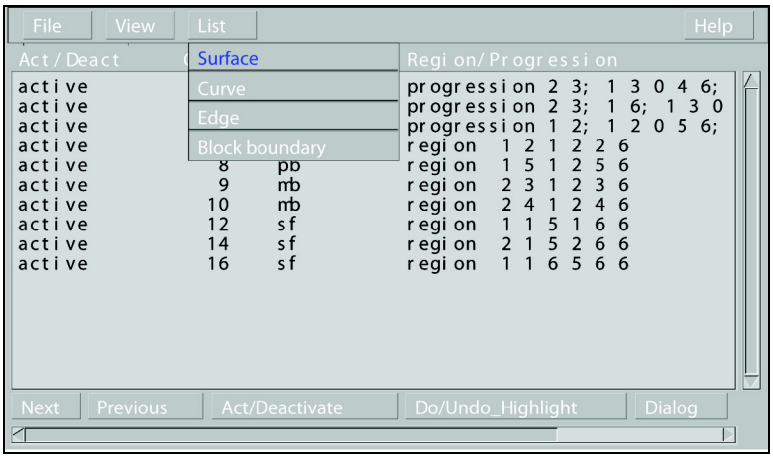


Figure 309 List dependencies

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

actcmd activate a mesh command previously deactivated

actcmd *command_sequence_#*

Remarks

This command re-activates a mesh command within the scope of the presently generated part. It is automatically issued when the history window is used to activate a command.

When a part is generated, the meshing commands are saved in command tables. Each new meshing command causes the mesh to be re-initialized so that the entire mesh can be re-generated. This re-generation is automatic and is accomplished by executing all of the commands in the command tables, in their proper order (i.e. according to the command hierarchy). The command tables can be viewed using the history table. It is possible to deactivate a command from the command tables using the **decmd** command. This will also cause the mesh to be re-generated. A command that was deactivated with the **decmd** commands can be re-activated with the **actcmd** command. Use the history table to determine the command sequence number. This sequence number is the argument to the **actcmd** command.

Both the physical and computational graphics can only be re-drawn after the mesh is re-generated. As usual, the part is not actually re-generated until a graphics command is issued.

decmd deactivate a mesh command

decmd *command_sequence_#*

Remarks

This command deactivates a mesh command within the scope of the presently generated part. It is automatically issued when the history window is used to deactivate a command.

When a part is generated, the meshing commands are saved in a command table. Each new meshing command causes the mesh to be re-initialized so that the entire mesh can be re-generated. This re-generation is automatic and is accomplished by executing all of the commands in the command tables, in their proper order. The command tables can be viewed with the history table. It is possible to deactivate a command in the command tables using the **decmd** command. This will also cause the mesh to be re-generated. A command that was deactivated with the **decmd** commands can be activated with the **actcmd** command. Use the history table to determine the command sequence number. This sequence number is the argument to the **decmd** command.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This command has a side effect in the graphics. Both the physical and computational graphics can only be re-drawn after the mesh is re-generated. As usual, the part is not actually re-generated until a graphics command is issued.

undo deactivate the last active mesh command

undo *(no arguments)*

Remarks

This command only deactivates mesh commands that operate on the part being generated. It can be issued as many times as needed to step backward in the command sequence for the part being generated. It has no effect on the graphics environment or the data base defined by commands such as **curd** for 3D curves or **sd** for surfaces. It can only undo up to the **block** or **cylinder** command. To undo the **block** or **cylinder** command, issue the **abort** command. The **abort** command can be issued anytime in the part phase.

The **decmd** accomplishes the same function. A command that has been deactivated with the **undo** command can be reactivated using the **actcmd** command.

This command has a graphical side effect. Both the physical and computational windows will be re-drawn after the mesh is re-generated.

Each time the ***undo*** button in the environment window is clicked, this **undo** command is automatically issued.

9. Select Regions For Display

These commands let you select only some of the regions of a part to be displayed. Such selective viewing can be very useful for a complicated part with many regions. For example, you can look "inside" of a complicated part. This can be done by peeling away the top layer of the mesh. Only the reduced index faces and edges of the mesh are displayed in the graphics, so by peeling away the top layer, you can expose the next layer of reduced index faces and edges. This makes it possible to view the skeleton of the mesh.

These commands select regions that already exist: they cannot add or delete regions from the mesh. Only those regions which have not been deleted can be displayed.

When a region is selected for interactive mouse movement, the entire region outline is animated, even if only part of the region was selected by these commands to be displayed.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The default is to display all regions of a part.

These commands are available only in the Part Phase.

When a selection is made by one of these commands, both the physical and computational graphics windows will be redrawn to reflect the new regions to be displayed.

It is not possible to display just a vertex, but you can display just the edges or faces adjacent to a point.

In a complex part with many regions, create several command files, each containing a set of selection commands to display a subset of the mesh. Then use the **include** command each time you wish to display that part of the mesh.

The alternative to using these commands is to select a part of the mesh with the mouse either by clicking and/or click-and-drag actions on the index bars in the computational window or by the other equivalent methods. Then select the ***Display List*** button in the environment window in order to reveal the ***Display List*** panel of options. Click on the ***Region*** button on the left and choose the appropriate action on the right.

arg add a region to the display

arg *region*

Example

```
block 1 8;1 8;1 8;1 2 1 2 1 2
rg 1 1 1 1 2 2
arg 2 1 1 2 2 2
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

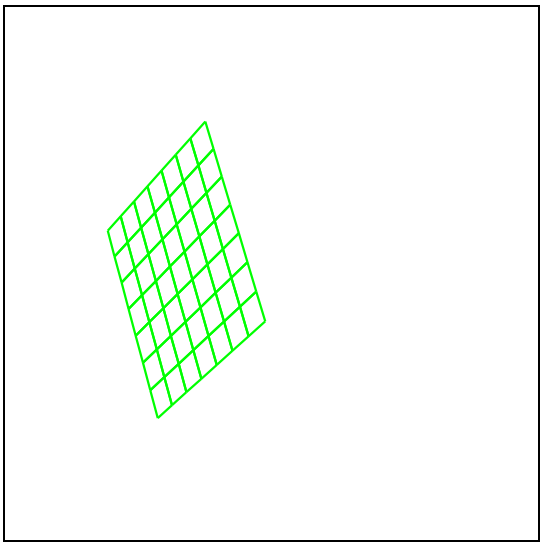


Figure 310 Before ARG

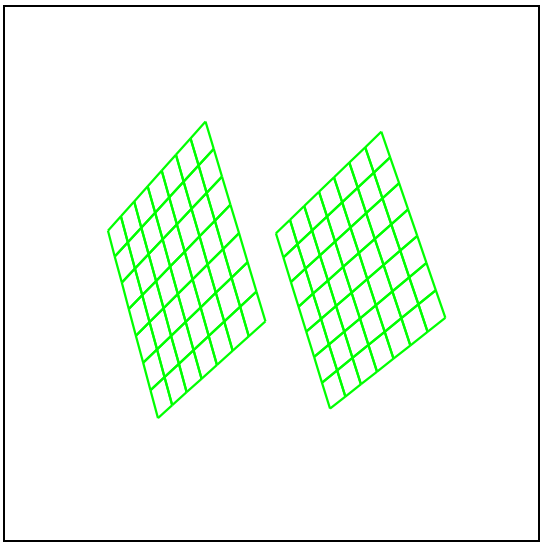


Figure 311 Add A Region

argi add a progression to the display

argi *progression*

Example

```
sd 1 sp 9 9 9 4
block 1 5 13 17;1 5 13 17;1 5 13 17;
      1 5 13 17;1 5 13 17;1 5 13 17;
sfi -2 -3; -2 -3; -2 -3;
sd 1
rg 3 1 1 3 4 4
argi 2 3;-2 -3;-2 -3;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

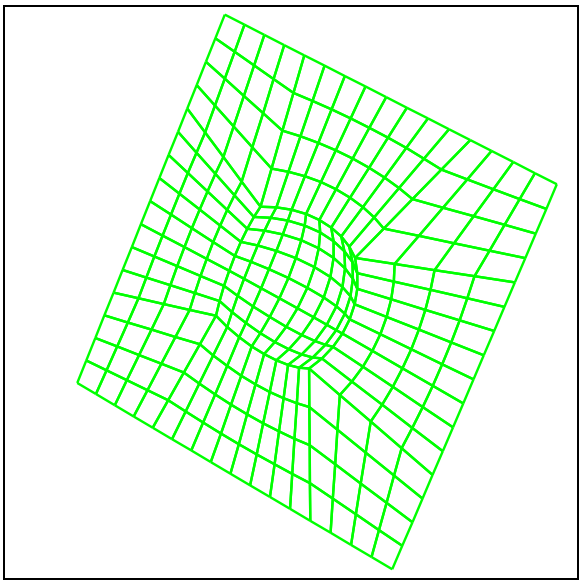


Figure 312 Before ARGI

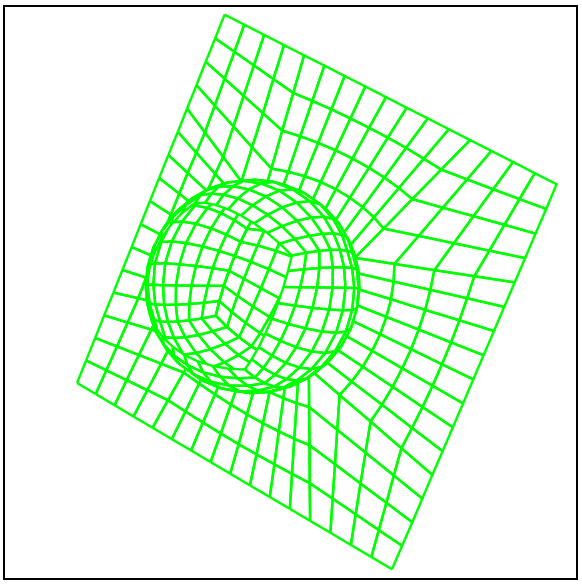


Figure 313 Add regions

darg display all regions

darg <*no arguments*>

Example

```
sd 1 sp 9 9 9 4
block 1 5 13 17;1 5 13 17;1 5 13 17;
      1 5 13 17;1 5 13 17;1 5 13 17;
sfi -2 -3; -2 -3; -2 -3;
sd 1
rgi -1 0 -2 0 -3 0 -4;;;
darg
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

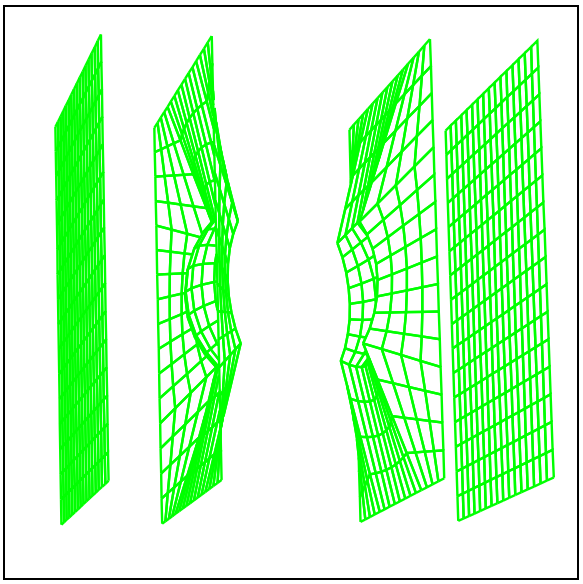


Figure 314 Region Selection Using **rg**

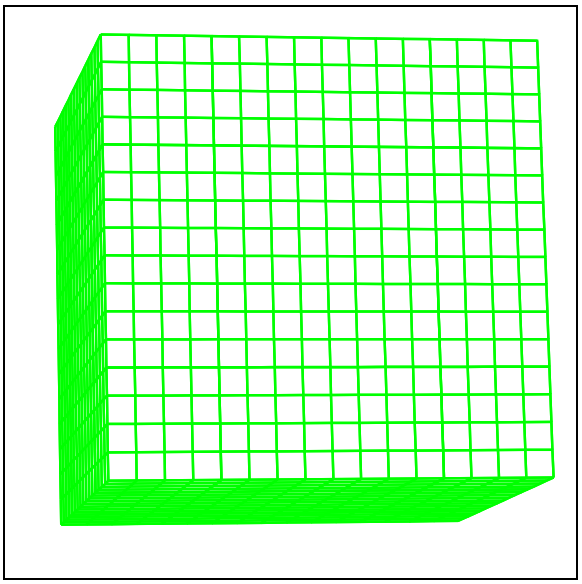


Figure 315 All regions selected

darged display all edges

darged <*no arguments*>

Example

```
sd 1 sp 9 9 9 4
block
 1 5 13 17;1 5 13 17;1 5 13 17;
 1 5 13 17;1 5 13 17;1 5 13 17;
sfi -2 -3; -2 -3; -2 -3;
sd 1
darged
```

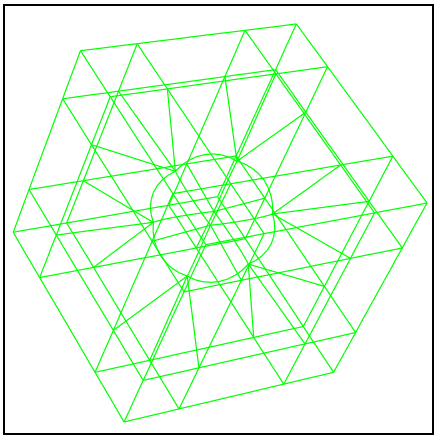


Figure 316 Region Edges

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rg display a region

rg *region*

Example

```
sd 1 sp 9 9 9 4
block 1 5 13 17;1 5 13 17;1 5 13 17;
     1 5 13 17;1 5 13 17;1 5 13 17;
sfi -2 -3; -2 -3; -2 -3;sd 1
rg 3 1 1 3 4 4
```

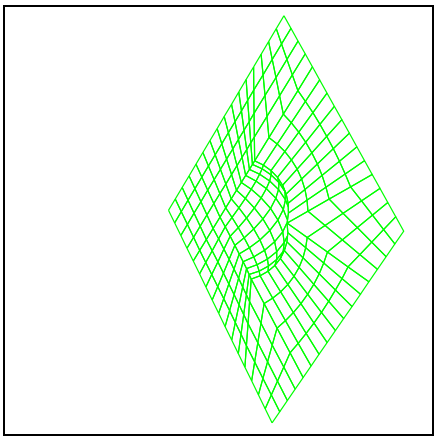


Figure 317 One Region Selected

rgi display a progression

rgi *progression*

Example

```
sd 1 sp 9 9 9 4
block 1 5 13 17;1 5 13 17;1 5 13 17;
     1 5 13 17;1 5 13 17;1 5 13 17;
sfi -2 -3; -2 -3; -2 -3;sd 1
rgi -2 0 -3; ; ;
```

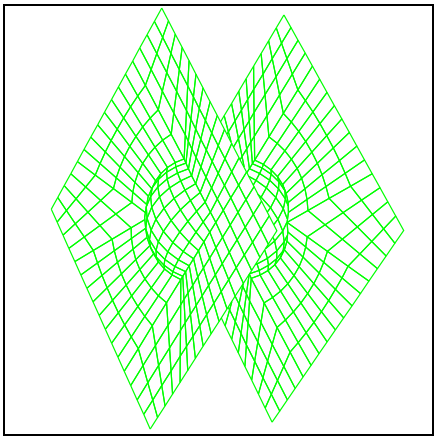


Figure 318 Multi-Region

rrg remove a region from display

rrg *region*

Example

```
sd 1 sp 9 9 9 4
block 1 5 13 17;1 5 13 17;1 5 13 17;
      1 5 13 17;1 5 13 17;1 5 13 17;
sfi -2 -3; -2 -3; -2 -3;sd 1
rrg 1 1 4 4 4 4
```

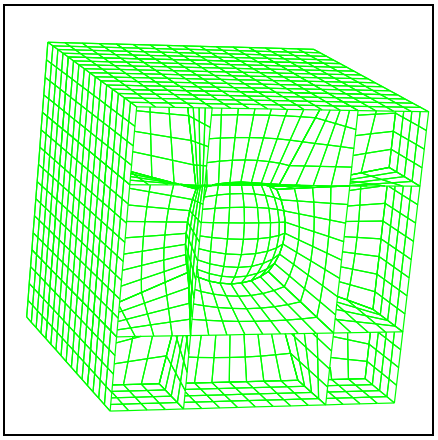


Figure 319 Front Face Removed

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rrgi remove a progression from display

rrgi *progression*

Example

```
sd 1 sp 9 9 9 4
block 1 5 13 17;1 5 13 17;1 5 13 17;
      1 5 13 17;1 5 13 17;1 5 13 17;
sfi -2 -3; -2 -3; -2 -3;sd 1
rrgi -1 -4;-1 -4;-1 -4;
```

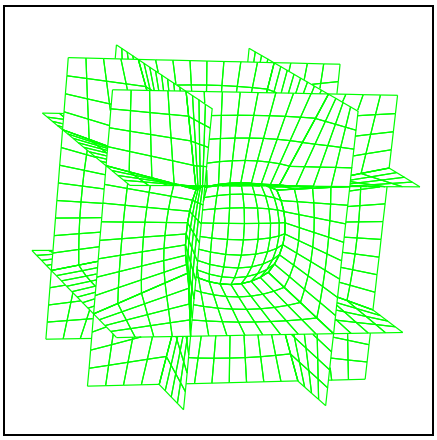


Figure 320 Outer Faces Removed

strghl highlight region

strghl *region*

Remarks

This has the same effect as selecting a region in the computational window. It is useful when building a demonstration input file.

strghli highlight index progression

strghl *progression*

Remarks

This has the same effect as selecting a progression in the computational window. It is useful when building a demonstration input file.

Example

```
block
1 3 5 7 8 9;1 2 3 4 5;1 3 4 6;
1 2 3 4 5 6;1 2 3 4 5;1 2 3 4;
strghli -1 3 0 -4 5;-2 -3 0 -4 5;3 4;
```

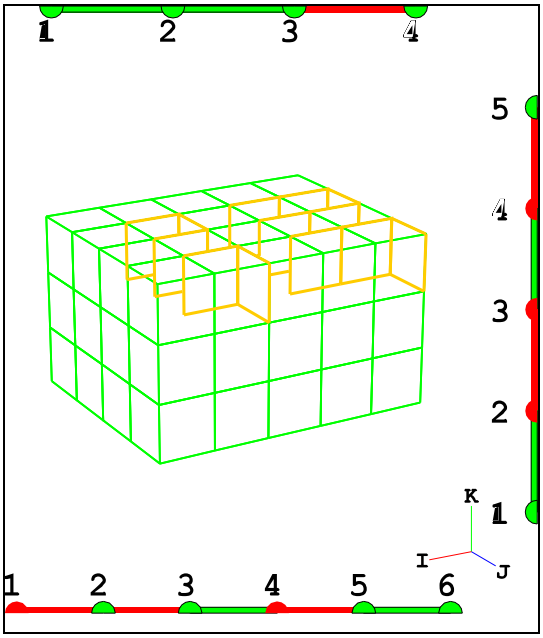


Figure 321 highlighted progression

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

clrghl clear highlighted selection

clrghl (no arguments)

Remarks

Typing the **F2** function key has the same effect as this command.

10. Labels in the Picture

labels specify type of label to be displayed

labels *option*

where the *option* can be any of:

off	to turn off labels display
sd	to display numbers of defined surfaces
bb	to display numbers of block boundaries
crv	to display numbers of defined 3D curves
sdedge	to display surface edge identification numbers
sdpt	to display labels of points on defined surfaces
parts	to display labels of previously generated parts
crvpt	to display labels of points on defined 3D curves

11. Displacements, Velocities, and Accelerations

These commands specify displacements, velocities, and accelerations, usually for initial or boundary conditions. In most of them, the arguments take the form

region load_curve amplitude x y z

or

progression load_curve amplitude x y z

The condition is applied to the nodes of the given region or index progression. The displacement, velocity, etc. is applied in the direction given by the vector (x, y, z), which might be in Cartesian, cylindrical, or spherical coordinates. For some simulation codes like DYNA3D, the magnitude of the condition is the *product* of the *amplitude* and the current value of the load curve. In this case, the load

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

curve is a time-dependent function given by the load curve number, *load_curve*. In some other simulation codes, such as ABAQUS, the load curve number is associated with a step, and in other simulation codes like NASTRAN, the load curve number is associated with a load case or set id. The latter 2 cases are referred to as load set identification numbers in the menus and dialogue boxes.

Displacements, Velocities, and Accelerations refer to the local coordinate system of a part, so the directions and amplitudes of displacements, velocities and accelerations do not change by replication of a part.

fd fixed displacement

fd *region load_curve amplitude options* $f_x f_y f_z$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction of the load

Remarks

At each node in the region, the displacement will have a direction given by the direction vector (*fx*, *fy*, *fz*).

fdi fixed displacement by index progression

fdi *progression load_curve amplitude options* $f_x f_y f_z$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

where

(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction of the load

Remarks

This is the same as **fd**, except that it applies to all nodes in an index progression.

Example

A mesh is defined in Cartesian coordinates. Null load curve is referenced (0). Displacement in Cartesian coordinates is assigned by index progression. The simplified command file follows:

```
block 1 5;1 5;-1;
      -2.5 2.5;-2.5 2.5;0;
      c mesh definition

fdi ;-2 ;-1;0 1 1 1 0
      c fixed displacement
      c definition
      c null load curve (0)
      c is used
      c amplitude 1
      c direction 1 1 0

merge

co fd 0
      c display of fixed
      c displacement
```

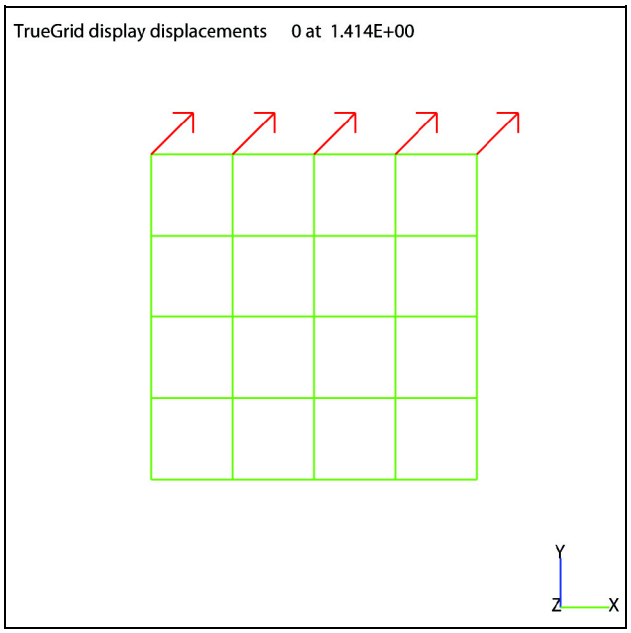


Figure 322 Fixed displacement

fdc cylindrical fixed displacement

fdc *region load_curve amplitude options ρ θ z*

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

where

(ρ, θ, z)	is a vector (in cylindrical coordinates) giving the direction of the displacement. The angle is in degrees.

Remarks

This is the same as **fd**, except that the direction is in cylindrical coordinates.

fdci cylindrical fixed displacement

fdci *progression load_curve amplitude options* ρ θ z

where

load_curve	is a load curve or case number or zero,
amplitude	is an amplitude factor, and

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, z)	is a vector (in cylindrical coordinates) giving the direction of the displacement. The angle is in degrees.

Remarks

This is the same as **fdc**, except that it applies to all nodes in an index progression. This is the same as **fd**, except that it applies to an index progression and uses cylindrical coordinates.

Example

A mesh is defined in Cartesian coordinates. Null load curve is referenced (0). Displacement in cylindrical coordinates is assigned by index progression. The simplified command file follows:

```
block 1 5;1 5;-1;
      -2.5 2.5;-2.5 2.5;0;
      c mesh definition
```

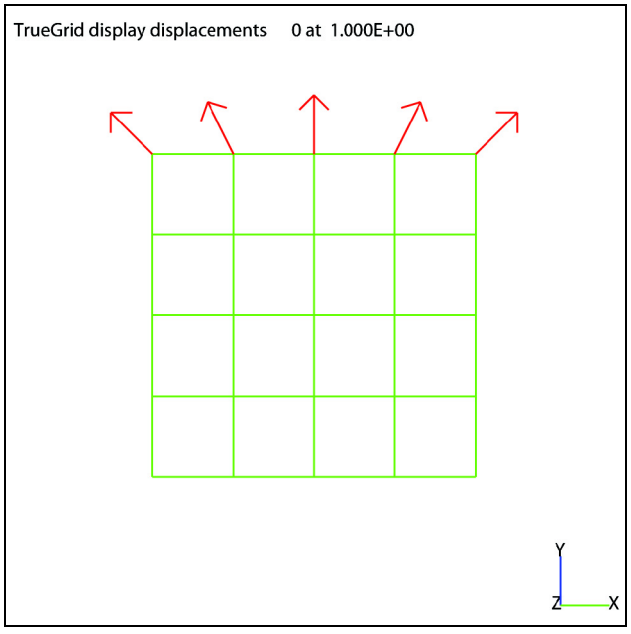


Figure 323 cylindrical fixed displacement

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
fdci ;-2 ;-1;0 1 1 0 0
 c cylindrical fixed disp.
 c assigned by ;-2 ;-1;
 c load curve 0
 c magnitude 1
 c direction 1 0 0
merge
co fd 0
c display fixed displacement 0
```

fds spherical fixed displacement

fds *region load_curve amplitude options ρ θ φ*

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, φ)	is a vector (in spherical coordinates) giving the direction of the displacement. The angles are in degrees.

Remarks

This is the same as **fd**, except that the direction is in spherical coordinates.

fdsi spherical fixed displacement

fdsi *progression load_curve amplitude options ρ θ φ*

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

(ρ, θ, φ) is a vector (in spherical coordinates) giving the direction of the displacement. The angles are in degrees.

Remarks

This is the same as **fds**, except that it applies to all nodes in an index progression. This is the same as **fd**, except that it applies to an index progression and uses spherical coordinates.

Example

A mesh is defined and projected onto the sphere in Cartesian coordinates. Sphere is centered at the origin. Null load curve is referenced (0). Displacement in spherical coordinates is assigned by index progressions `3 4;2 4;;` and `2 3;2 3;;` (**Figure 324**). The simplified command file follows:

```
block 1 3 5 7 9;1 3 5 7 9;-1;
-2 -1 0 1 2;-2 -1 0 1 2;0;
     c mesh definition
```

...projection of the mesh onto the sphere...

```
fdsi 3 4;2 4; ;0 1 4 0 0
 c spherical fixed disp.
 c by index progression
 c 3 4;2 4;;
 c null load curve
 c magnitude 1
 c direction 4 0 0

fdsi 2 3;2 3; ;0 1 4 0 0
 c spherical fixed disp.
 c by index progression
 c 2 3;2 3;;
 c null load curve
 c magnitude 1
 c direction 4 0 0
merge
co fd 0   display of fixed displacement 0
```

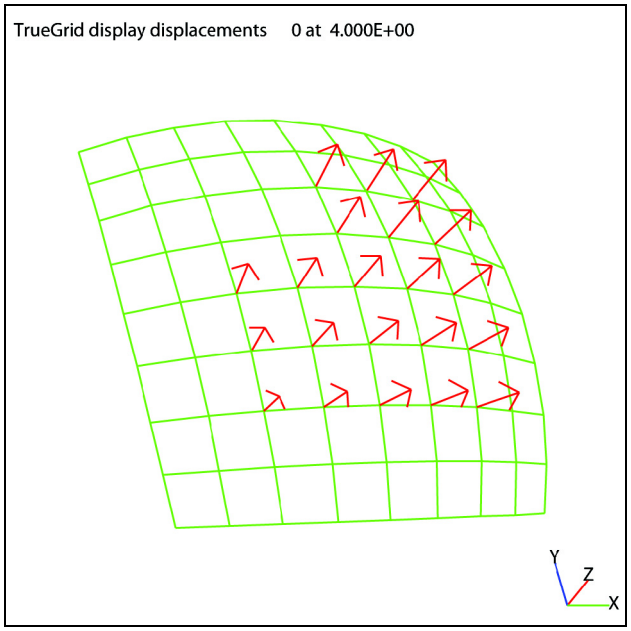


Figure 324 cylindrical fixed displacement

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

frb prescribed nodal rotation

frb *region load_# amplitude options condition direction*

where *options* can be any of the following

birth *time*
death *time*
o**ffset** $offset_1$ $offset_2$

where *condition* must be one of the following

v	velocities
a	accelerations
d	displacements
dofv	nodal dof velocities
dofa	nodal dof accelerations
dofd	nodal dof displacements

where *direction* must be one of the following

x	about the x-axis
y	about the y-axis
z	about the z-axis
v x_0 y_0 z_0	about an arbitrary axis
ex	not about the x-axis
ey	not about the y-axis
ez	not about the z-axis
ev x_0 y_0 z_0	not about an arbitrary axis

Remarks

A condition can be a velocity, acceleration, displacement, or a nodal rotation. This is suited for Dyna3D (velocities, accelerations, and nodal rotations) and Lsdyna. In these codes, the selected nodes are prescribed this condition relative to an axis of rotation.

Use the **frb** option in the **co** merge phase command in the merge phase to display these conditions.

frbi prescribed nodal rotation by index progression

frbi *progression load_# amplitude options condition direction*

where *options* can be any of the following

birth *time*
death *time*
o**ffset** $offset_1$ $offset_2$

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

where *condition* must be one of the following

v	velocities
a	accelerations
d	displacements
dofv	nodal dof velocities
dofa	nodal dof accelerations
dofd	nodal dof displacements

where *direction* must be one of the following

x	about the x-axis
y	about the y-axis
z	about the z-axis
v x_0 y_0 z_0	about an arbitrary axis
ex	not about the x-axis
ey	not about the y-axis
ez	not about the z-axis
ev x_0 y_0 z_0	not about an arbitrary axis

Remarks

A condition can be a velocity, acceleration, displacement, or a nodal rotation. This is suited for Dyna3D (velocities, accelerations, and nodal rotations) and Lsdyna. In these codes, the selected nodes are prescribed this condition relative to an axis of rotation.

Use the **frb** option in the **co** merge phase command in the merge phase to display these conditions.

fv prescribed velocities

fv *region load_curve amplitude options* f_x f_y f_z

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction of the velocities

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

At each node in the region, the velocity will have a direction given by the direction vector (*fx*, *fy*, *fz*).

Example

A mesh is defined and projected onto the cylinders in cylindrical coordinates. Null load curve is referenced (0). Velocity in Cartesian coordinates is assigned by regions `2 1 1 2 13 2` and `1 1 2 2 13 2`. The simplified command file follows:

... mesh definition ...

```
fv 2 1 1 2 13 2 0 1 0 0 -1
 c fixed velocity prescribed
 c   to region 2 1 1 2 13 2
 c null load curve 0
 c magnitude 1
 c direction 0 0 -1

fv 1 1 2 2 13 2 0 1 0 0 -1
 c fixed velocity prescribed
 c   to region 1 1 2 2 13 2
 c null load curve 0
 c magnitude 1
 c direction 0 0 -1

merge

co fv 0
 c display of fixed velocity
 c for load curve 0
```

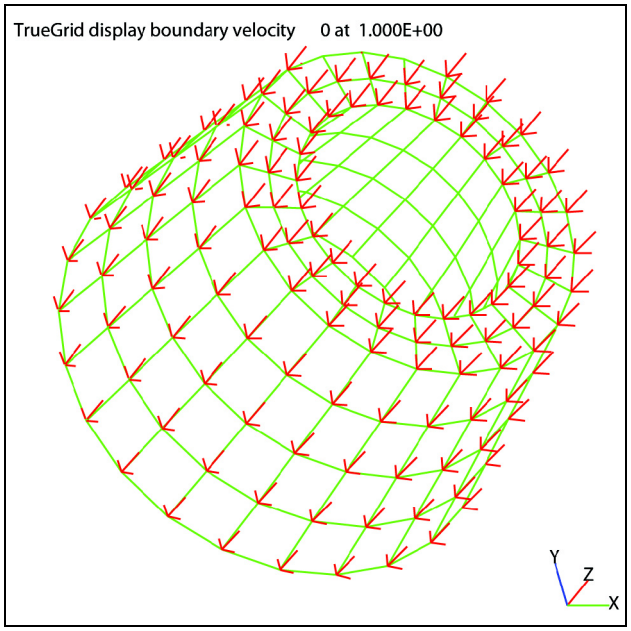


Figure 325 fixed velocity prescribed

fvi prescribed velocities

fvi *progression load_curve amplitude options* $f_x f_y f_z$

where

load_curve	is a load curve number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction of the velocities

Remarks

This is the same as **fv**, except that it applies to all nodes in an index progression.

fvc cylindrical prescribed velocities

fvc *region load_curve amplitude options* ρ θ *z*

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, z)	is a vector (in cylindrical coordinates) giving the direction of the velocity. The angle is in degrees.

Remarks

This is the same as **fv**, except that the direction is in cylindrical coordinates.

fvci cylindrical prescribed velocities

fvci *progression load_curve amplitude options* ρ θ *z*

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

where

(ρ, θ, z)	is a vector (in cylindrical coordinates) giving the direction of the velocity. The angle is in degrees.

Remarks

This is the same as **fvc**, except that it applies to all nodes in an index progression. This is the same as **fv**, except that it applies to an index progression and uses cylindrical coordinates.

fvs spherical prescribed velocities

fvs *region load_curve amplitude options* $\rho\ \theta\ \varphi$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, φ)	is a vector (in spherical coordinates) giving the direction of the velocity. The angles are in degrees.

Remarks

This is the same as **fv**, except that the direction is in spherical coordinates.

fvsi spherical prescribed velocities by index progression

fvsi *progression load_curve amplitude options* $\rho\ \theta\ \varphi$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor, to be multiplied by the load curve

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, φ)	is a vector (in spherical coordinates) giving the direction of the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

velocity. The angles are in degrees.

Remarks

This is the same as **fvs**, except that it applies to all nodes in an index progression. This is the same as **fv**, except that it applies to an index progression and uses spherical coordinates.

bv prescribed boundary surface velocities for NEKTON

bv *region fx fy fz*

bvi prescribed boundary surface velocities for NEKTON

bvi *progression fx fy fz*

acc prescribed boundary acceleration

acc *region load_curve amplitude options* $f_x f_y f_z$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction of the acceleration

Remarks

At each node in the region, the acceleration will have a direction given by the direction vector (*fx*, *fy*, *fz*).

Example

Mesh and load curve 1 are defined. Acceleration is assigned to the region. The caption refers to the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

load_curve_# **1** with the maximum size of the vector 1.044E+00. The simplified command file follows:

```
block 1 5;1 5;1 3;1 5;1 5;1 3;      c mesh definition
lcd 1 0 0 1 1;                      c load curve 1 definition
acc 1 1 2 2 2 2 1 1 .3 0 -1         c acceleration definition
     c for region 1 1 2 2 2 2
     c load curve 1
     c amplitude 1
     c direction .3 0 -1.
merge
set tv disp                         c hide mode
co size 7                           c size of arrow
co acc 1                            c display acceleration arrows
```

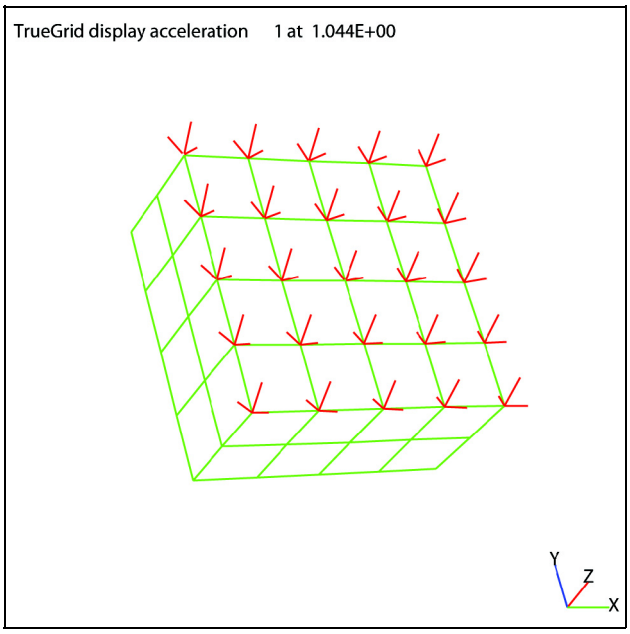


Figure 326 acceleration by acc

acci prescribed boundary acceleration

acci *progression load_curve amplitude options* $f_x f_y f_z$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction of the acceleration

Remarks

This is the same as **acc**, except that it applies to an index progression.

accc cylindrical prescribed boundary acceleration

accc *region load_curve amplitude options* $\rho\ \theta\ z$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, z)	is a vector (in cylindrical coordinates) giving the direction of the acceleration. The angle is in degrees.

Remarks

This is the same as **acc**, except that the direction is in cylindrical coordinates.

accci cylindrical prescribed boundary acceleration

accci *progression load_curve amplitude options* $\rho\ \theta\ z$

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

death *time* specify ending time (for Lsdyna)

where

(ρ, θ, z) is a vector (in cylindrical coordinates) giving the direction of the acceleration. The angle is in degrees.

Remarks

This is the same as **accc**, except that it applies to an index progression. This is the same as **acc**, except that it applies to an index progression and uses cylindrical coordinates.

Example

```
cylinder 1 3;1 3 5 7 9 11 13 15 17 19 21 23 25;1 11;
     2 3;0 30 60 90 120 150 180 210 240 270 300 330 360;0 10;
lcd 1 0 1 1 1; accci -2; ; ;1 1 1 0 0 merge
condition acc 1                c display accelerations
```

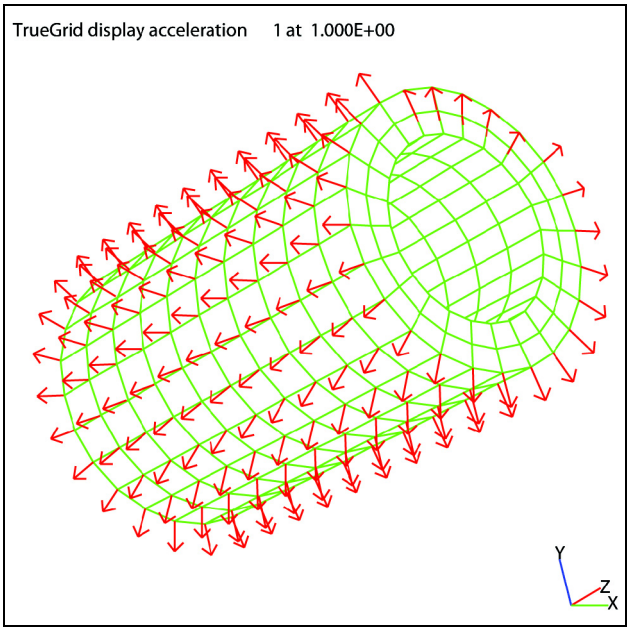


Figure 327 radial acceleration

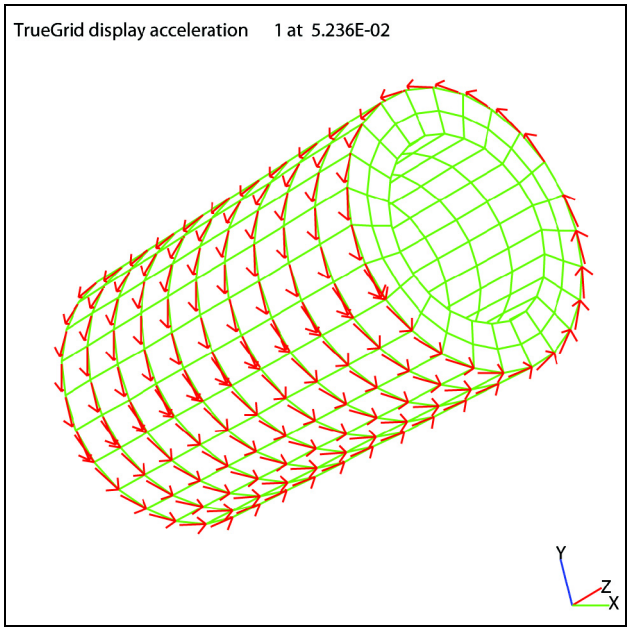


Figure 328 acceleration in the angular direct.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

accs spherical prescribed boundary acceleration

accs *region load_curve_# amplitude options ρ θ φ*

where

region	must be a vertex, edge, or face
load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor, to be multiplied by the load curve

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, φ)	is a vector (in spherical coordinates) giving the direction of the acceleration The angles are in degrees.

Remarks

This is the same as **acc**, except that the direction is in spherical coordinates.

accsi spherical prescribed boundary acceleration

accci *progression load_curve amplitude options ρ θ φ*

where

load_curve	is a load curve or case number or zero
amplitude	is an amplitude factor

where *options* can be any of

exclude	exclude normal directions (for Lsdyna)
birth *time*	specify starting time (for Lsdyna)
death *time*	specify ending time (for Lsdyna)

where

(ρ, θ, φ)	is a vector (in spherical coordinates) giving the direction of the acceleration

Remarks

This is the same as **accs**, except that it applies to an index progression. This is the same as **acc**, page 311, except that it applies to an index progression and uses spherical coordinates.

Example

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

A mesh is defined in Cartesian coordinates. Load curve 1 is defined. Acceleration in cylindrical coordinates is assigned by index progression. The simplified command file follows:

```
block 1 5;1 5;1 3;
      -2.5 2.5;-2.5 2.5;1 3;
      c mesh definition

lcd 1 0 0 1 1;
      c load curve 1 definition

accsi ; ;-2;1 1 1 0 0
 c acceleration
 c load curve 1, amplitude 1
 c direction in cyl. coord.
 c  is 1. 0. 0.
merge
co acc 1
  c display of acceleration 1
```

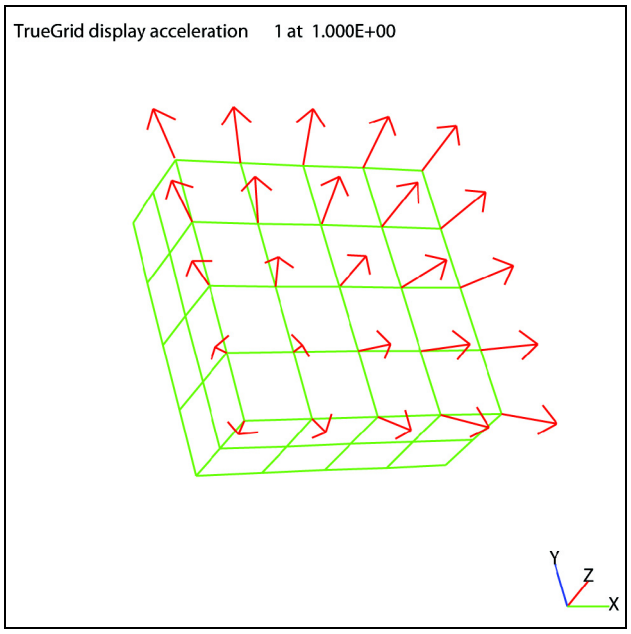


Figure 329 spherical acceleration

dis initial displacement in a region

dis *region option* v_x v_y v_z

where an option can be

sid set_id_#

r for rotational conditions

where

(v_x,v_y,v_z) is the velocity vector.

Remarks

An initial displacement is assigned to all nodes in the specified region.

Some simulation codes require that initial displacements be group togther and that is the purpose for the set id. This command can also be used to set initial nodal rotational displacements using the **r** option.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

disi initial displacement by index progression

disi *progression option* v_x v_y v_z

where an option can be

sid set_id_#

r for rotational conditions

where

(v_x,v_y,v_z) is the velocity vector.

Remarks

For details, see **dis** above.

fvv variable prescribed nodal boundary velocities

fvv *region load_curve_# amp_expr ; x-expr ; y-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
x-expr	is the FORTRAN expression for the x-component
y-expr	is the FORTRAN expression for the y-component
z-expr	is the FORTRAN expression for the z-component

Remarks

This command assigns velocities, allowing for the amplitude factor and the Cartesian vector components to be calculated using a FORTRAN expression. Each expression can reference the nodal coordinates X, Y, and Z and the nodal indices I, J, and K.

When the part is generated in cylindrical coordinates, the X in an expression will refer to the radial coordinate of the node and Y in an expression will refer to the angular coordinate of the node.

Example

For example, the velocities are specified by the command:

```
fvv 1 1 1 2 2 2 0 abs(x)+abs(y)+abs(z);cos(z*10);sin(z*10); 0;
```

This command sets the velocities for an entire block, controlled by the load curve number 0. The amplitude is calculated from the absolute values of the three nodal coordinates. The x and

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

y-components of the vector are trigonometric functions of the z-coordinate of the node. The z-component of the vector is 0.

```
block  1 3;1 3;1 3;
     1 3;1 3;1 3;
     c mesh definition

fvv 1 1 1 2 2 2 0
 abs(x)+abs(y)+abs(z);
 cos(z*10);  sin(z*10); 0;
  c variable prescribed
  c velocity for region
  c 1 1 1 2 2 2
  c null load curve
merge
co fv 0
     c display of the velocity
```

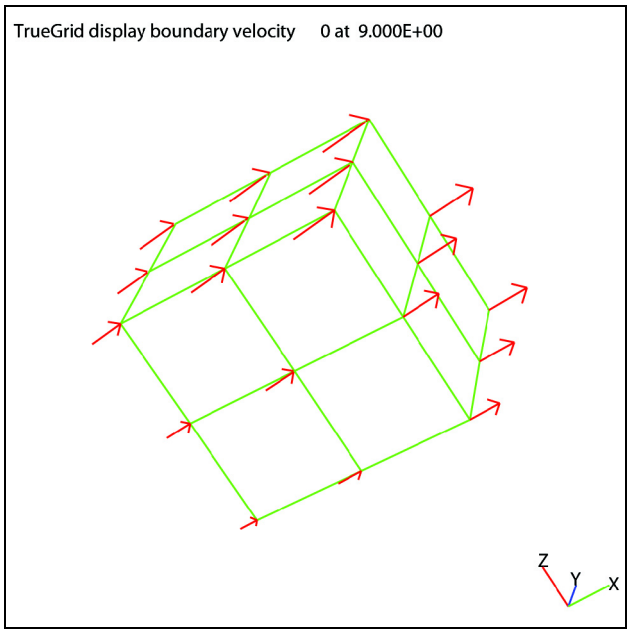


Figure 330 variable velocity prescribed

fvvi variable prescribed nodal boundary velocities

fvvi *progression load_curve_# amp_expr ; x-expr ; y-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
x-expr	is the FORTRAN expression for the x-component
y-expr	is the FORTRAN expression for the y-component
z-expr	is the FORTRAN expression for the z-component

Remarks

See **fvv** for remarks. The only difference is that regions are selected using index progressions.

Example

Mesh is defined in Cartesian coordinates. Variable velocity is prescribed by index progression `;-2;-1;` with the variable amplitude `sin(atan2(y,2*x))` and direction `0 1 0`. The simplified command file follows:

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
block 1 10;1 10;-1;
     -2.5 2.5;-2.5 2.5;0;
     c mesh definition

fvvi   ;-2   ;-1;   0
sin(atan2(y,2*x)); 0; 1; 0;
 c variable velocity prescrib.
 c  by index progression
 c  ;-2;-1;
 c null load curve (0)
 c magnitude sin(atan2(y,2*x))
 c direction 0 1 0
merge
co fv 0
     c display of the velocity
```

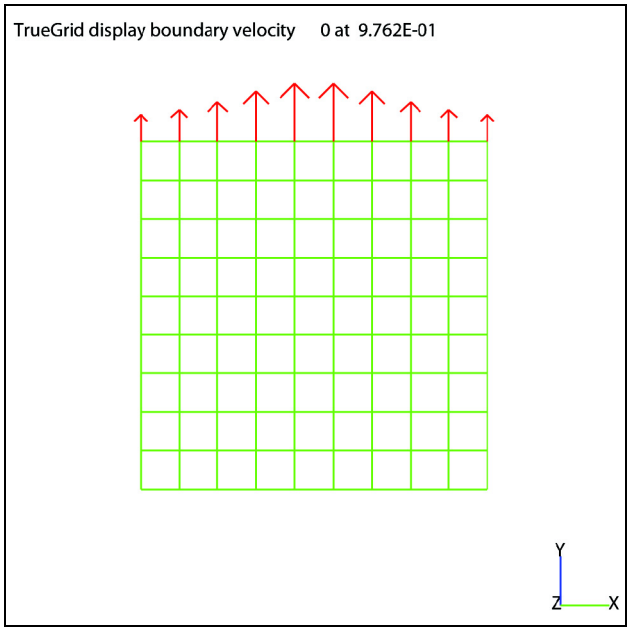


Figure 331 variable velocity prescribed

fvvc cylindrical variable nodal prescribed boundary velocities

fvvc *region load_curve_# amp_expr ; ρ-expr ; θ-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
z-expr	is the FORTRAN expression for the z-component

Remarks

This command assigns velocities, allowing for the amplitude factor and the cylindrical vector components to be calculated using a FORTRAN expression. Each expression can reference the nodal coordinates X, Y, and Z and the nodal indices I, J, and K. When the part is generated in cylindrical coordinates, the X in an expression will refer to the radial coordinate of the node and Y in an expression will refer to the angular coordinate of the node.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

fvvci cylindrical variable prescribed nodal boundary velocities

fvvci *progression load_curve_# amp_expr ; ρ-expr ; θ-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
z-expr	is the FORTRAN expression for the z-component

Remarks

See **fvvc** for remarks. The only difference is that regions are selected using index progressions.

Example

A mesh is defined in cylindrical coordinates. Cylindrical variable velocity is prescribed for the outer surface of cylinder part by index progression. The velocity has cosine magnitude depending on one half of angle θ. The simplified command file follows:

... mesh definition ...

```
lcd 1 0 1 1 1;
     c load curve 1 definition

fvvci -2; ; ;1 cos(y/2);
 1; 0; 0;
     c variable cylindrical
     c  velocity definition
     c load curve 1
     c magnitude cos(y/2)
     c direction 1 0 0

merge

condition fv 1
     c display of prescribed
     c velocity
```

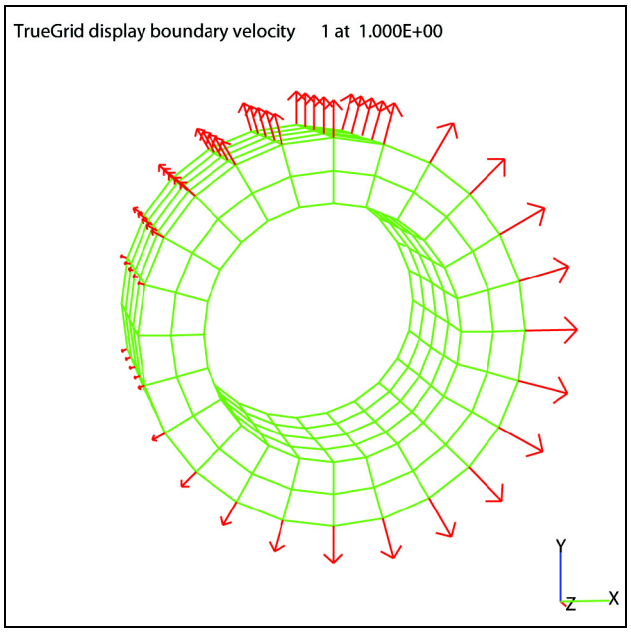


Figure 332 cylindrical variable velocity

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

fvvs spherical variable prescribed nodal boundary velocities

fvvs *region load_curve_# amp_expr ; ρ-expr ; θ-expr ; φ-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
φ-expr	is the FORTRAN expression for the φ-component

Remarks

This command assigns velocities, allowing for the amplitude factor and the spherical vector components to be calculated using a FORTRAN expression. Each expression can reference the nodal coordinates X, Y, and Z and the nodal indices I, J, and K. When the part is generated in cylindrical coordinates, the X in an expression will refer to the radial coordinate of the node and Y in an expression will refer to the angular coordinate of the node.

fvvsi spherical variable prescribed nodal boundary velocities

fvvsi *progression load_curve_# amp_expr ; ρ-expr ; θ-expr ; φ-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
φ-expr	is the FORTRAN expression for the φ-component

Remarks

See **fvvs** for remarks. The only difference is that regions are selected using index progressions.

vacc variable prescribed nodal boundary accelerations

vacc *region load_curve_# amp_expr ; x-expr ; y-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
x-expr	is the FORTRAN expression for the x-component

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

y-expr	is the FORTRAN expression for the y-component
z-expr	is the FORTRAN expression for the z-component

Remarks

This command assigns accelerations, allowing for the amplitude factor and the Cartesian vector components to be calculated using a FORTRAN expression. Each expression can reference the nodal coordinates X, Y, and Z and the nodal indices I, J, and K. When the part is generated in cylindrical coordinates, the X in an expression will refer to the radial coordinate of the node and Y in an expression will refer to the angular coordinate of the node.

vacci variable prescribed nodal boundary accelerations

vacci *progression load_curve_# amp_expr ; x-expr ; y-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
x-expr	is the FORTRAN expression for the x-component
y-expr	is the FORTRAN expression for the y-component
z-expr	is the FORTRAN expression for the z-component

Remarks

See **vacc** for remarks. The only difference is that regions are selected using index progressions.

vaccc cylindrical variable nodal prescribed boundary accelerations

vaccc *region load_curve_# amp_expr ; ρ-expr ; θ-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
z-expr	is the FORTRAN expression for the z-component

Remarks

This command assigns accelerations, allowing for the amplitude factor and the cylindrical vector components to be calculated using a FORTRAN expression. Each expression can reference the nodal

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

coordinates X, Y, and Z and the nodal indices I, J, and K. When the part is generated in cylindrical coordinates, the X in an expression will refer to the radial coordinate of the node and Y in an expression will refer to the angular coordinate of the node.

vaccci cylindrical variable prescribed nodal boundary accelerations

vaccci *progression load_curve_# amp_expr ; ρ-expr ; θ-expr ; z-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
z-expr	is the FORTRAN expression for the z-component

Remarks

See **vaccc** for remarks. The only difference is that regions are selected using index progressions.

Example

A mesh is defined in cylindrical coordinates. Cylindrical variable acceleration is prescribed for the outer surface of cylinder part by index progression. The acceleration has linear magnitude depending on `z+1` expression. The simplified command file follows:

```
vaccci -2; ; ;0 z+1; 1; 0; 0;
 c variable cylindrical accel.
 c null load curve used 0
 c magnitude z+1
 c direction 1 0 0
merge
condition acc 0 c display of
acceleration
```

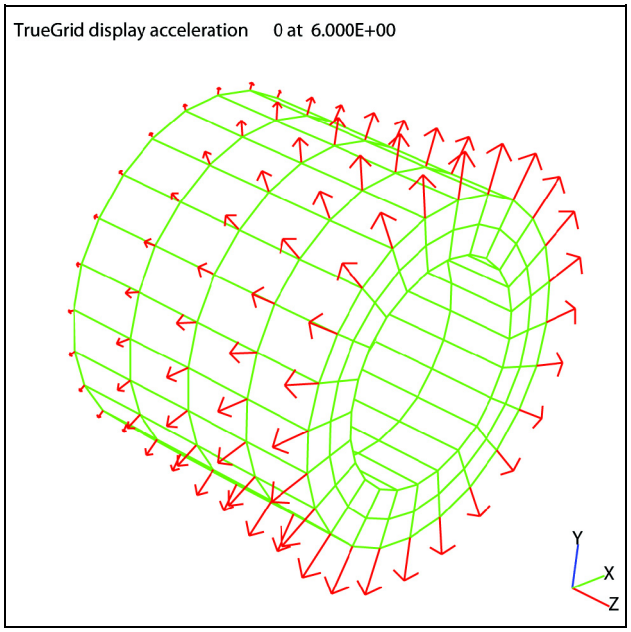


Figure 333 variable cylindrical acceleration

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

vaccs spherical variable prescribed nodal boundary accelerations

vaccs *region load_curve_# amp_expr ; ρ-expr ; θ-expr ; φ-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
φ-expr	is the FORTRAN expression for the φ-component

Remarks

This command assigns accelerations, allowing for the amplitude factor and the spherical vector components to be calculated using a FORTRAN expression. Each expression can reference the nodal coordinates X, Y, and Z and the nodal indices I, J, and K. When the part is generated in cylindrical coordinates, the X in an expression will refer to the radial coordinate of the node and Y in an expression will refer to the angular coordinate of the node.

vaccsi prescribed nodal boundary accelerations (spherical)

vaccsi *progression load_curve_# amp_expr ; ρ-expr ; θ-expr ; φ-expr ;*

where

load_curve_#	is a load curve or case number or zero
amp_expr	is the FORTRAN expression for the amplitude
ρ-expr	is the FORTRAN expression for the radial-component
θ-expr	is the FORTRAN expression for the polar angular-component
φ-expr	is the FORTRAN expression for the φ-component

Remarks

See **vaccs** for remarks. The only difference is that regions are selected using index progressions.

rotation part initial rigid body rotation

rotation *x0 y0 z0 x_rotation y_rotation z_rotation*

where

(x0,y0,z0)	is any point on the axis of rotation.
(x_rotation,y_rotation,z_rotation)	is the rotation vector in radians per unit time.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

An initial rigid body rotation is assigned to the part. This command will override any **rotation** or **velocity** commands issued in the Control Phase, but just for this one part. The **ve** or **vei** commands in the Part Phase can override this command for just a few regions of this part.

velocity part initial velocity

velocity v_x v_y v_z
where
(v_x,v_y,v_z) is the velocity vector.

Remarks

An initial rigid velocity is assigned to all nodes of the part. This command will override any **rotation** or **velocity** commands issued in the control phase, but just for this one part. The **ve** or **vei** commands in the Part Phase can override this command for just a few regions of this part.

ve initial velocity in a region

ve *region option* v_x v_y v_z
where an option can be
sid set_id_#
r for rotational conditions
where
(v_x,v_y,v_z) is the velocity vector.

Remarks

An initial velocity is assigned to all nodes in the specified region. This command will override any **rotation** or **velocity** commands issued in either the Control Phase or the Part Phase, for the specified region.

Some simulation codes require that initial velocities be group together and that is the purpose for the set id. This command can also be used to set initial nodal rotations using the **r** option.

vei initial velocity by index progression

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

vei *progression option* v_x v_y v_z

where an option can be

sid set_id_#

r for rotational conditions

where

(v_x,v_y,v_z) is the velocity vector.

Remarks

For details, see **ve** above.

12. Force, Pressure, and Loads

These commands specify forces, pressures, loads, or other such conditions. In most of them, the arguments take the form

region load_curve amplitude x y z

or

progression load_curve amplitude x y z

The load curve is not appropriate for some commands and do not appear in the command. The condition is applied to the given region or index progression, or just to the nodes in it. It is applied in the direction given by the vector (x, y, z), which might be in Cartesian, cylindrical, or spherical coordinates. For some simulation codes like Dyna3d, the magnitude of the load is the *product* of the *amplitude* and the current value of the load curve. In this case, the load curve is a time-dependent function given by the load curve number, *load_curve*. In some other simulation codes, such as Abaqus, the load curve number is used to associate the load with a step (see **abaqstep**), and in other simulation codes like Nastran, the load curve number actually identifies the load case.

arri modify pressure amplitudes and shock arrival time

arri *ld_curve_# list_options* ;

where

option must be

velo *velocity*

toff *time_off_set*

point *x0 y0 z0* (Shock shape - sphere)

line *x0 y0 z0 xn yn zn* (Shock shape - infinite cylinder)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

(*x0 y0 z0* - point on line, *xn yn zn* - direction vector of line)
plane *x0 y0 z0 xn yn zn* (Shock shape - infinite plane)
(*x0 y0 z0* - point in plane, *xn yn zn* - normal vector of plane)
laser *distribution_# x0 y0 z0 xn yn zn*
(*x0 y0 z0* - point on line, *xn yn zn* - direction vector of laser beam)
cosine (calculate angle of incidence)
cg *maximum_pressure*
cl *minimum_pressure*
decay decay *option*
where
option must be
constant for no decay
r (for decay/distance)
r2 (for (decay/distance)**2)
r3 (for (decay/distance)**3)
exp *exp* (for (decay/distance)**ep)
linear *y_intercept* (for y_intercept+decay*distance)

Remarks

Use the **pr** or **pri** command to initiate a pressure face. Use the **fl**, **fli**, **efl**, or **efli** commands to initiate a flux boundary face. Amplitudes for **fl**, **fli**, **efl**, or **efli** commands are the absolute value of the calculated value. The load curve or load case number is used to associate this command with the appropriate pressure/flux faces. The origin of the shock can be a **point** (**Figure 334**), infinite **line** (**Figure 335**), infinite **plane** (**Figure 336**), or a **laser** beam (**Figure 337**).

The shock arrival time is based on the distance between the center of the pressure/flux face and the source of the shock. The starting time and shock speed should be specified. The **cosine** option calculates the angle of incidence. All pressure/flux faces have their amplitudes modified when the **cosine** option is selected. The angle between the normal of the pressure/flux face and the vector from each node of the pressure/flux face to the source is calculated. Then the pressure amplitude at the node is scaled by the cosine of the angle. This is done for each node of each pressure/flux face.

When the **laser** beam is the source, an additional damping factor is calculated. This is based on the perpendicular distance of each node from the laser beam (**d**) (**Figure 337**). There are two types of laser calculations: Gaussian and tabular. This laser scale function is defined with the **dist** command.

The **decay** option is also used to scale nodal pressure amplitudes by distance from the source of the shock (**r**) (**Figure 334**,**Figure 335**,**Figure 336**,**Figure 337**). The function can be based on distance, distance squared, distance cubed, exponential, or linear. The decay distance for a laser is the distance

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

in the beam direction only (**Figure 337**).

The **minimum** and **maximum** pressure amplitude can be specified. It causes "cut off" values which are out of range **minimum** and **maximum**. If a **minimum** is not selected and the **cosine** is selected, then the **minimum** defaults to zero.

The **cosine**, **decay**, **laser**, **minimum**, and **maximum** amplitude can be combined. The **point**, **line**, **plane**, and **laser** are mutually exclusive.

The resulting face value is given by:

$$\text{value} = \textit{amplitude} \times \cos(\Theta) \times \text{decayfactor}(\textit{decay},r) \times \text{dampingfactor}(d,\textit{dist})$$

where:

amplitude	is the amplitude in the source
Θ	is the angle between the source vector and the normal vector of the face
decay	is an arbitrary constant
r	is the distance from the source
d	is the perpendicular distance from the source for laser option
dist	is the perpendicular distribution function for the laser option

The arrival time is always non-negative. If the **laser** option is selected and if the target is behind the laser, then the amplitudes are set to zero. It is also possible that the center of the pressure/flux face is in front of the laser beam, receiving a positive arrival time, while some of the nodes of the pressure face are behind the laser, receiving a zero amplitude. If there are several **arri** commands issued for the same pressure face with the same load curve or load case number, the one with the smallest arrival time will be used, excluding arrivals due to the pressure/flux face being behind a laser beam. If no shock arrival is found for a pressure/flux face, then the pressure amplitudes specified by the **pr**, **pri**, **fl**, **fli**, **efl**, and **efli** commands are left unchanged and the shock arrival time is set to zero.

Orientation of the normal vectors of the faces can be specified by the **orpt** command.

Example

The mesh is defined by a structured block (**Figure 334**). The load curve `1` is determined by points `0 0 1 1`. Pressure with amplitude `10000` is assigned to the region `4 1 1 4 6 6`. A point source of shock is defined by coordinates `15,13,13`. The velocity of the shock is `1000` and time offset is `0`. The amplitude of the shock decays with cube of the distance (**r**) from the shock source. The angle of incidence option is used to calculate the amplitude in normal direction of the faces.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
Jpglcd 1 0 0 1 1;
 c load curve 1 definition
pr 4 1 1 4 6 6 1 10000
 c pressure is assigned
 c to region 4 1 1 4 6 6
 c by load curve 1
 c and amplitude 10000
arri 1 velo 1000 toff 0
     point 15 13 13
     cosine decay 1 r3 ;
 c shock arrival
 c for load curve 1
 c with velocity 1000
 c and time offset 0
 c from point source
 c with coord. (15,13,13)
 c angle of incidence option
 c (cosine) is used
 c shock amplitude is decaying
with cube of distance
 c from shock source
merge
co pr 1          c display pressure for load curve 1
```

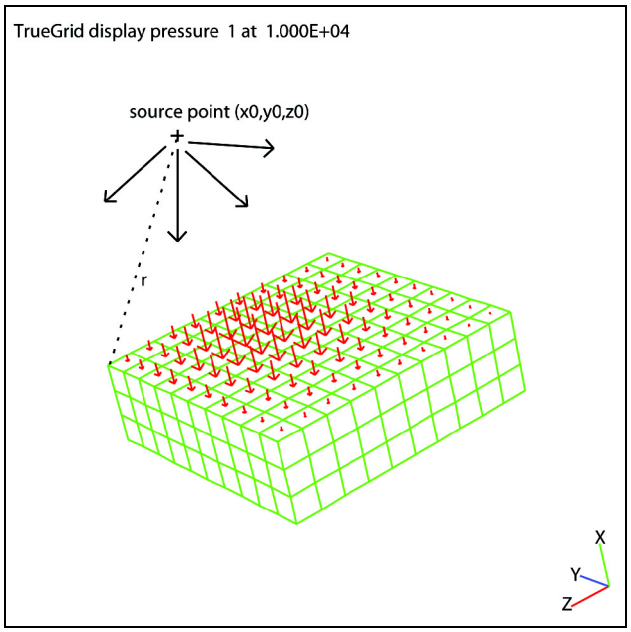


Figure 334 Point Source

Example

The mesh is defined by a structured block (**Figure 335**). The load curve `1` is determined by points `0 0 1 1`. Pressure with amplitude 30000 is assigned to the region `4 1 1 4 6 6`. A line source of shock is defined by coordinates `15,13,13 and -.1,1,1`. The velocity of the shock is `500` and time offset is `0`. The amplitude of the shock decays with square of the distance (**r**) from the shock source. The decay constant is `1`. The angle of incidence option is used to calculate the amplitude in normal direction of the faces.

```
lcd 1 0 0 1 1;
 c load curve 1 definition
pr 4 1 1 4 6 6 1 30000
```

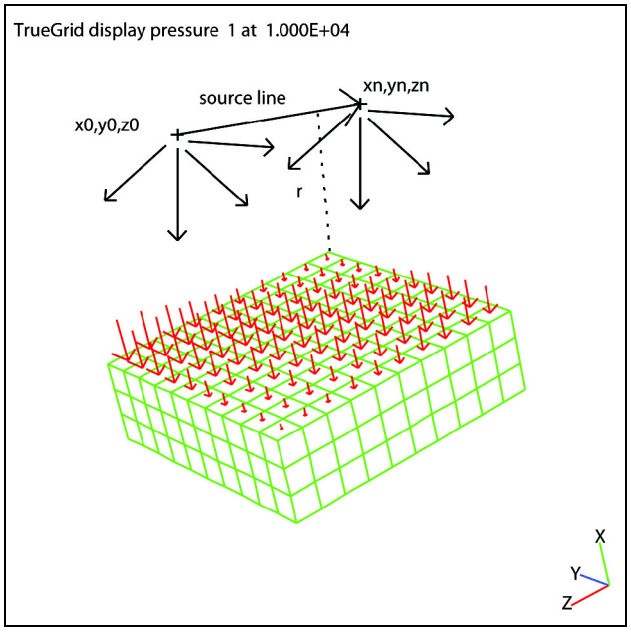


Figure 335 Line Source

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
 c pressure is assigned
 c to region 4 1 1 4 6 6
 c by load curve 1
 c and amplitude 30000
arri 1 velo 500 toff 0
     line 15 13 13 -.1 1 1
     cosine decay 1 r2 ;
 c shock arrival
 c for load curve 1
 c with velocity 500
 c and time offset 0
 c from line source
 c with coord. (15,13,13)
 c and (-.1,1,1)
 c angle of incidence option
 c (cosine) is used
 c shock amplitude is decaying with square of distance
 c from shock source
merge
co pr 1         c display pressure for load curve 1
```

Example

The mesh is defined by a structured block (**Figure 336**). The load curve `1` is determined by points `0 0 1 1`. Pressure with amplitude 10000 is assigned to the region `4 1 1 4 6 6`. A plane source of shock is defined by coordinate `15,13,13` and normal vector `1,0,0`. The velocity of the shock is `500` and time offset is `0`. The amplitude of the shock decays with square of the distance (**r**) from the shock source. The decay constant is `1`. The angle of incidence option is used to calculate the amplitude in normal direction of the faces.

```
lcd 1 0 0 1 1;
 c load curve 1 definition
pr 4 1 1 4 6 6 1 10000
 c pressure is assigned
 c to region 4 1 1 4 6 6
 c by load curve 1
 c and amplitude 10000
```

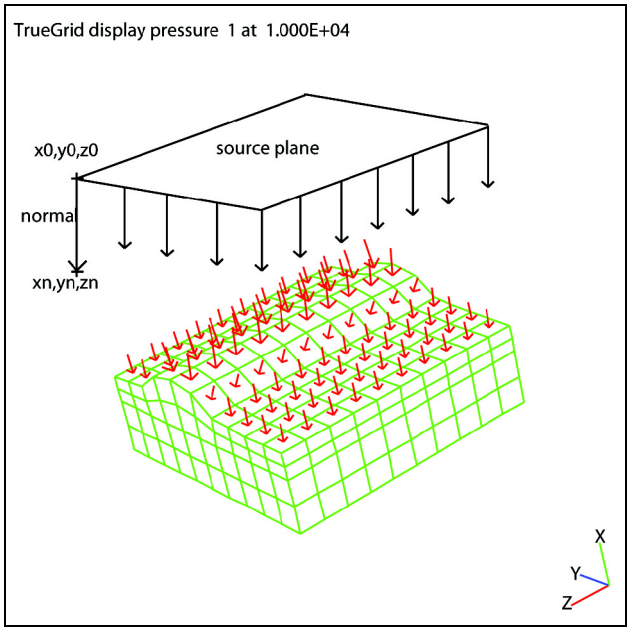


Figure 336 Plane Source

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
arri 1 velo 500 toff 0
     plane 15 13 13 1 0 0
     cosine decay 1 r2 ;
 c shock arrival
 c for load curve 1
 c with velocity 500
 c and time offset 0
 c from plane source
 c with coord. (15,13,13)
 c and normal(1,0,0)
 c angle of incidence option
 c (cosine) is used
 c shock amplitude is decaying with square of distance
 c from shock source
merge
co pr 1        c display pressure for load curve 1
```

dist laser distribution function

dist *distribution_# type parameter_list*
where *type* and *parameter_list* can be
gaus *coefficient_1 coefficient_2 coefficient_3*
table *list_2D_points* ;

Remarks

dist creates a laser scale function for the **arri** command. This is functional when the **laser** option is selected. There are two types of functions: Gaussian and tabular.

The Gaussian has the form:

$$dist = \frac{a^{\frac{-(distance-b)^2}{2c^2}}}{c}$$

where a, b, and c are specified and distance is the variable **d** in **Figure 337**.

The tabular form is a polygonal function. Pairs of coordinates form a function where the first coordinate of each pair must be strictly monotonically increasing.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

The load curve `1` is determined by points `0 1 1 1`. Pressure with amplitude `10000` is assigned to the region `1 1 1 1 2 2`. A laser source of shock is defined by a point with coordinates `4,.5,.5` and a direction vector `-1,0,0`. The velocity of the shock is `500` and time offset is `0`. The amplitude of the laser shock is damped according to table defined by the **dist** command. The table in **dist** command describes a multiplier of shock amplitude varying by perpendicular distance from the laser beam. The command file follows:

```
block
 -1;1 21;1 21;0;-2 2;-2 2;
  c mesh definition
lcd 1 0 1 1 1;
  c load curve 1 definition
pr 1 1 1 1 2 2 1 10000
  c pressure is assigned
  c to region 1 1 1 1 2 2
  c by load curve 1
  c with amplitude 10000
arri 1 velo 1.e6
     laser 1 4 .5 .5 -1 0 0 ;
  c laser shock for
  c load curve 1
  c with velocity 1.e6
  c with distribution 1
  c and point (4,.5,.5)
  c direction vector (-1,0,0)
dist 1 table 0 5 1 2 2 0  ;
c distribution 1 given by table
0 5 1 2 2 0
merge
co pr 1        c display pressure for load curve 1
```

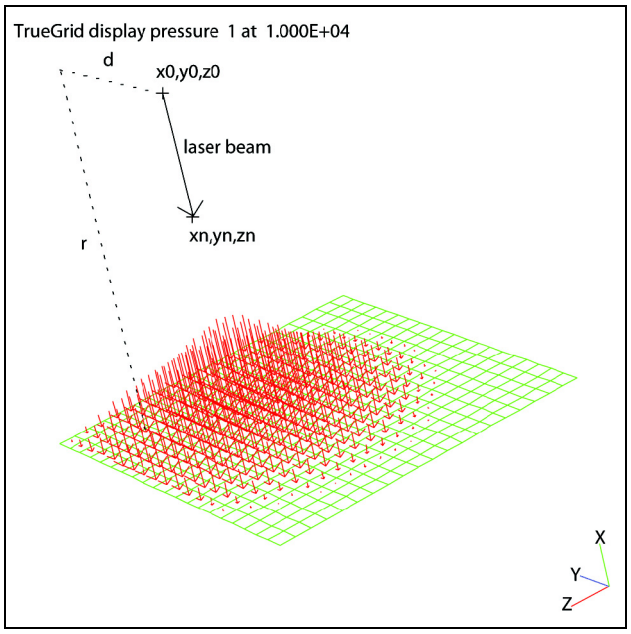


Figure 337 Laser Beam

csf cross section forces for DYNA3D

csf *region cross_section_# before_or_after*
where before_or_after is 0 or 1, respectively

fa fixed nodal rotations

fa *region* θ_x θ_y θ_z

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

fai fixed nodal rotations

fai *progression* θ_x θ_y θ_z

Remarks

This is the same as **fa**, except that it applies to an index progression.

fc concentrated nodal loads

fc *region load_curve amplitude* f_x f_y f_z

where

load_curve	is a load curve number or zero
amplitude	is an amplitude factor
(f_x, f_y, f_z)	is a vector (in Cartesian coordinates giving the direction of the load)

Remarks

At each node in the region, the load will have a direction given by the direction vector (*fx*, *fy*, *fz*). The loads will be concentrated at the nodes. Some codes doing dynamic simulations will require a time dependent load curve used to ramp or vary the load with respect to time. Use **lcd** or **flcd** to create a numbered load curve. This load curve must then be reference in the **fc** command. The load can be turned off globally by assigning a constant zero to the load curve.
Some codes require a set id number so that all loads with the same set id number can be switched on or off globally. In these cases, assign a set id number instead of a load curve number. No load curve definition is required in this case. Other codes ignore this parameter, so just use a zero.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

A part is defined in Cartesian coordinates and the mesh is manipulated. The same concentrated nodal load is assigned to the nodes of the region `1 1 4 4 4 4` (**Figure 338**). The command file follows:

... definition of the mesh ...

```
fc 1 1 4 4 4 4 0 1 1 0 4
 c concentrated load is
 c  assigned
 c  to nodes of region
 c  1 1 4 4 4 4
 c by null load curve (0)
 c with amplitude 1
 c and direction 1 0 4

merge

co fc 0
 c display concentrated load
 c  for the null load curve
```

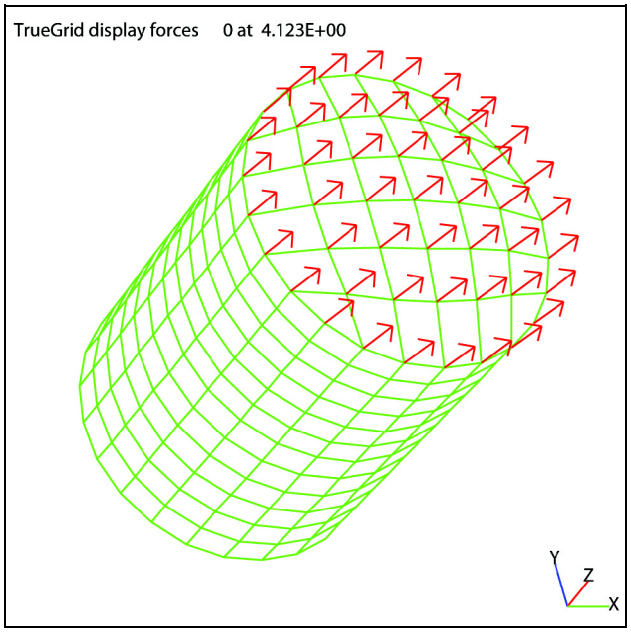


Figure 338 concentrated load

fci concentrated nodal loads

fci *progression load_curve amplitude* $f_x f_y f_z$

where

load_curve	is a load curve number or zero,
amplitude	is an amplitude factor, and
(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction of the load.

Remarks

This is the same as **fc**, except that it applies to all nodes in an index progression.

fcc cylindrical concentrated nodal loads

fcc *region load_curve amplitude* $\rho\ \theta\ z$

where

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

load_curve	is a load curve number or zero
amplitude	is an amplitude factor
(ρ, θ, z)	is a vector (in cylindrical coordinates) giving the direction of the displacement. The angle is in degrees.

Remarks

This is the same as **fc**, except that the direction is in cylindrical coordinates.

fcci cylindrical concentrated nodal loads

fcci *progression load_curve amplitude* $\rho\ \theta\ z$

where

progression	must be a set of vertices, edges, or faces
load_curve	is a load curve number or zero
amplitude	is an amplitude factor
(ρ, θ, z)	is a vector (in cylindrical coordinates) giving the direction of the displacement. The angle is in degrees.

Remarks

This is the same as **fcc**, except that it applies to all nodes in an index progression. This is the same as **fc**, except that it applies to an index progression and uses cylindrical coordinates.

Example

The part in this example has a cylindrical shape and it is defined in Cartesian coordinates with center in the local origin. The concentrated load is specified in the cylindrical coordinates with a -1 in the radial direction. It means, that the forces will point towards the axis of the symmetry of the cylinder (**Figure 339**). The command file follows:

... definition of the mesh ...

```
fcci -1; ; ;0 1 -1 0 0
 c concentrated load is
 c  assigned
```

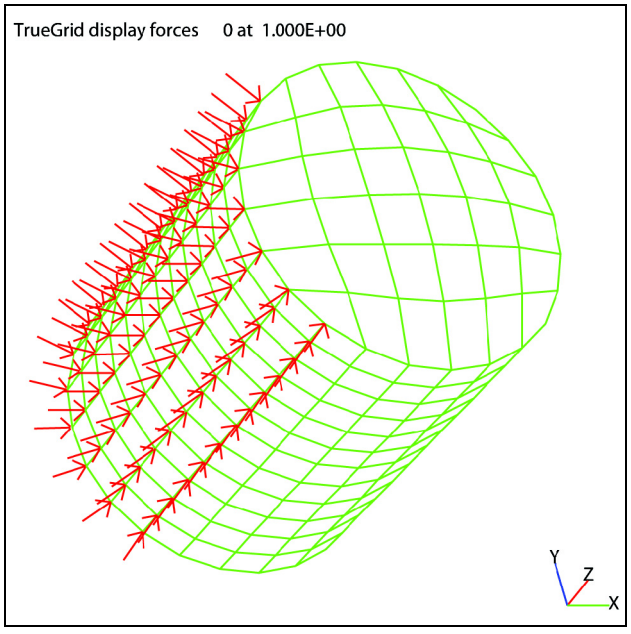


Figure 339 concentrated load

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
 c  to nodes of
 c index progression
 c  -1;;;
 c by null load curve (0)
 c with amplitude 1
 c and direction -1 0 0

merge

co fc 0
 c display concentrated load
 c  for null load curve
```

fcs spherical concentrated nodal loads

fcs region load_curve amplitude $\rho\ \theta\ \varphi$

where
region must be a vertex, edge, or face
load_curve is a load curve number or zero
amplitude is an amplitude factor
(ρ, θ, φ) is a vector (in spherical coordinates) giving the direction of the displacement. The angles are in degrees.

Remarks

This is the same as **fc**, except that the direction is in spherical coordinates.

fcsi spherical concentrated nodal loads

fcsi *progression load_curve amplitude* $\rho\ \theta\ \varphi$

where
load_curve is a load curve number or zero
amplitude is an amplitude factor
(ρ, θ, φ) is a vector (in spherical coordinates) giving the direction of the displacement. The angles are in degrees.

Remarks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This is the same as **fcs**, except that it applies to all nodes in an index progression. This is the same as **fc**, except that it applies to an index progression and uses spherical coordinates.

Example

The part in this example has a cylindrical shape and it is defined in Cartesian coordinates with center in the local origin. The concentrated load is specified in the spherical coordinates with a -1 in the radial direction. It means, that the forces will point towards the center of the spherical shape (**Figure 340**). Command file follows:

```
... definition of the mesh ...

fcsi ; ;-4;0 1 -1 0 0
 c concentrated load is
 c  assigned
 c  to nodes of
 c index progression
 c  ;;-4;
 c by null load curve (0)
 c with amplitude 1
 c and direction -1 0 0

merge

co fc 0
 c display concentrated load
 c  for null load curve
```

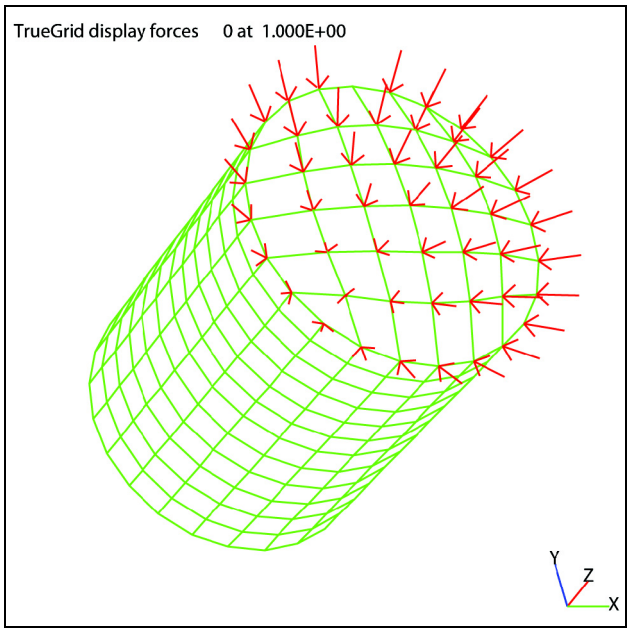


Figure 340 concentrated load

ll linearly interpolate loads by arc length

ll *region load_curve* $f_x f_y f_z$ $amplitude_{first\ node}$ $amplitude_{last\ node}$

where

load_curve	is a load curve number or zero
$amplitude_{first\ node}$	is the first amplitude for the interpolation
$amplitude_{last\ node}$	is the last amplitude for the interpolation
(f_x, f_y, f_z)	is a vector (in Cartesian coordinates) giving the direction.

Example

The mesh is defined by the structured block mesh. Linearly interpolated loads are prescribed to the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

nodes of the region `4 1 4 4 4 4` (**Figure 341**). The direction of the loads is `(5 3 0)`. The first node amplitude is `1000` and the last node amplitude is `6000`. The command file follows:

... mesh definition ...

```
ll
 4 1 4 4 4 4 0 5 3 0 1000 6000
 c linearly interpolated loads
 c are assigned to the nodes
 c of the edge 4 1 4 4 4 4
 c with direction 5 3 0
 c first node amplitude 1000
 c last node amplitude 6000

merge

co fc 0
 c display of concentrated
 c loads for the null load
 c curve
```

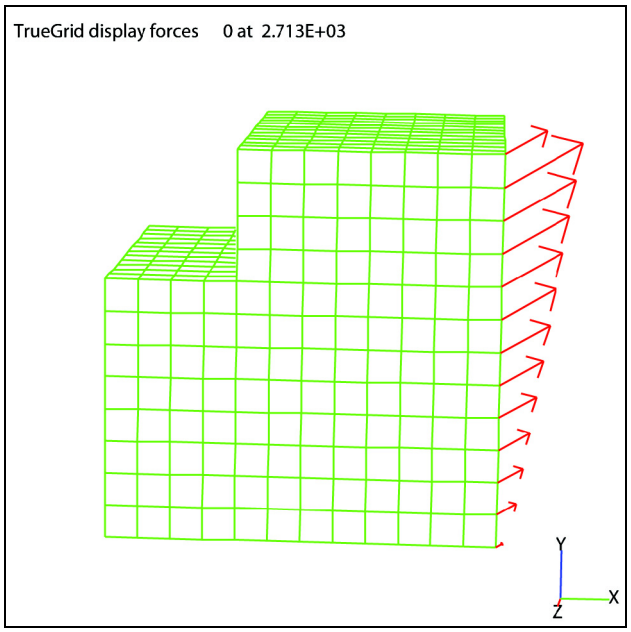


Figure 341 concentrated nodal,loads by ll

mdep momentum deposition

mdep *region x-momentum y-momentum z-momentum time*

where

x-momentum	x-direction momentum
y-momentum	y-direction momentum
z-momentum	z-direction momentum
time	deposition time

Remarks

This feature is used by dynamics codes like DYNA3D to simulate depositing momentum at specific elements at appropriate times. Each element in the specified region is assigned a momentum to be deposited at the selected time during the simulation.

Example

The mesh is defined by the structured block mesh. A region is deleted. Momentum deposition is

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

prescribed to the elements of the region (**Figure 342**). The command file follows:

```
block
 1 5 9 13; 1 5 9 13; 1 5 9 13;
1 5 9 13; 1 5 9 13; 1 5 9 13;
     c mesh definition

dei  1 2; 3 4;;

mdep 2 3 1 4 4 4 150 120 130 0
 c momentum deposition is
 c prescribed for the elements
 c of the region 2 3 1 4 4 4
 c with momentums 150 120 130
 c and deposition time 0

merge

co mdep
 c display of the elements
 c with prescribed deposition
 c of moment
```

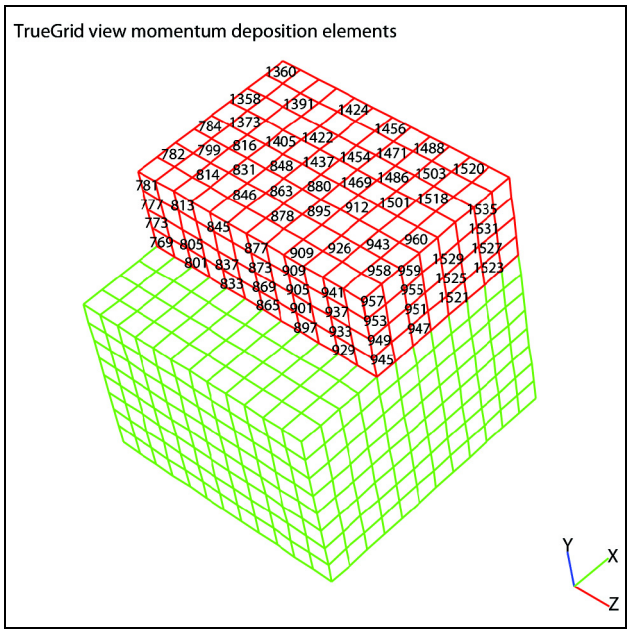


Figure 342 momentum deposition by mdep

mom nodal moment about an axis

mom *region load_curve moment direction*

where

direction specifies the axis and can be any of **x**, **y**, or **z**.

Remarks

Nodal moment about one of the nodal axis in the global coordinate system. Some codes doing dynamic simulations will require a time dependent load curve used to ramp or vary the moment with respect to time. Use **lcd** or **flcd** to create a numbered load curve. This load curve must then be reference in the **mom** command. The load can be turned off globally by assigning a constant zero to the load curve. Some codes require a set id number so that all moments with the same set id number can be switched on or off globally. In these cases, assign a set id number instead of a load curve number. No load curve definition is required in this case. Other codes ignore this parameter, so just use a zero.

Example

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

A part is defined in Cartesian coordinates and the mesh is manipulated. The nodal moment is assigned to the nodes of the region `2 2 1 2 3 2` (**Figure 343**). The command file follows:

... definition of the mesh ...

```
mom 2 2 1 2 3 2 0 153 z
 c nodal moment is
 c  assigned
 c  to nodes of
 c region
 c  2 2 1 2 3 2
 c by null load curve (0)
 c with amplitude 153
 c around z - axis

merge

co mom 0 z
 c display nodal moment
 c  for null load curve
 c  around z - axis
```

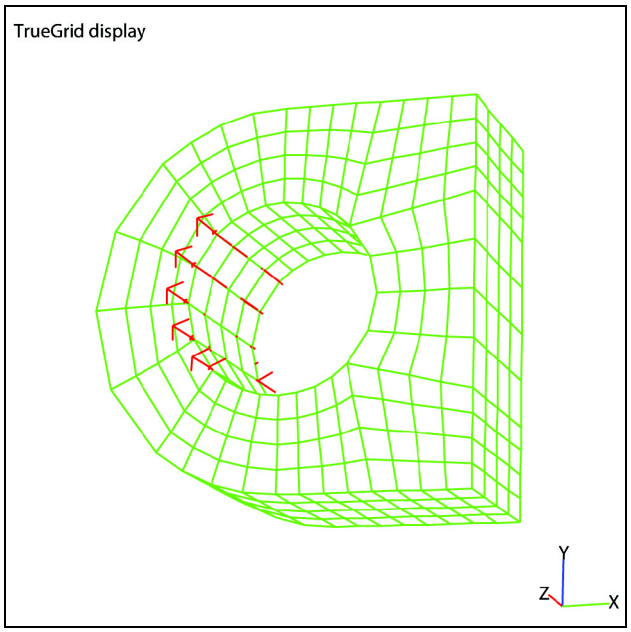


Figure 343 nodal moment

momi nodal moment about an axis

momi *progression load_curve moment direction*

where

load_curve	is a load curve number or zero
moment	magnitude of the moment
direction	specifies the axis of the moment and can be any of **x** , **y** , **z**

Remarks

The same as for **mom** command.

ndl nodal distributed load

ndl *region load_curve amplitude*

where

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

load_curve is a load curve number, or zero
amplitude is an amplitude factor

Remarks

This command specifies a load to be distributed on a surface. If the load curve argument is 0, that means there is no load curve. **True*Grid*®** will convert the pressure to nodal loads by multiplying the pressure by the surface area around each node.

The direction of the force is set to the direction of the normal to the face of the mesh at each node. **True*Grid*®** will naturally select a positive normal direction by default but it is best if you specify the positive direction by using the **orpt** command.

ndli nodal distributed load

ndli *progression load_curve amplitude*

where

load_curve is a load curve number or zero
amplitude is an amplitude factor

Remarks

This is the same as **ndl** except that it applies to an index progression. After nodes are merged by the **stp** command, the loads from merged nodes are added together.

Example

A part is defined in Cartesian coordinates and the mesh is manipulated. The direction of the normals is defined by the **orpt** command. The nodal distributed load is assigned to the faces of the index progressions `-1 0 2 3;-1 0 -4;; and -1;;;` (**Figure 344**). Then the concentrated nodal loads are computed from the distributed nodal load for each node of the assigned index progressions. The command file follows:

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

... definition of the mesh ...

```
orpt - 2 0 1.5
 c definition of direction
 c of every normal of face
 c the normals point out from
 c the point 2 0 1.5

ndli -1 0 2 3;-1 0 -4;;0 2800
 c distributed nodal load
 c is assigned
 c to the faces of the index
 c progression
 c -1 0 2 3; -1 0 -4;;
 c by the null load curve
 c with amplitude 2800

ndli -1;;;0 2800
 c distributed nodal load
 c is assigned
 c to the faces of the index
 c progression
 c -1;;;
 c by the null load curve
 c with amplitude 2800

merge

co fc 0   c display concentrated nodal loads for the null curve
          c the loads are not merged yet (use stp)
```

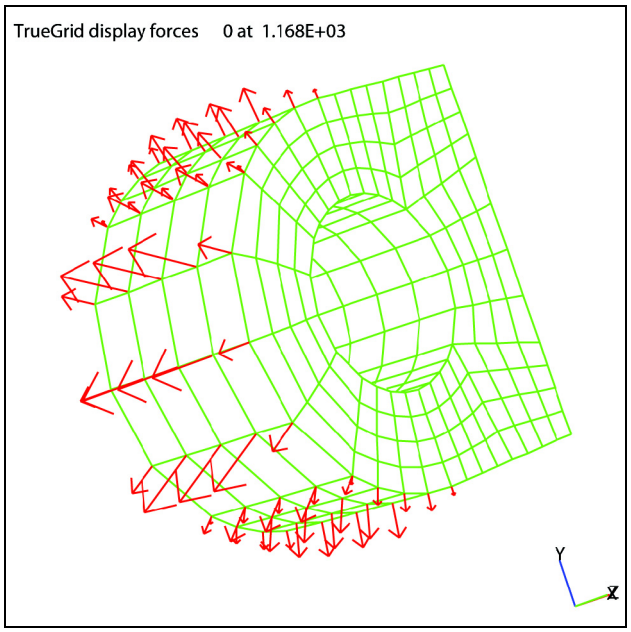


Figure 344 nodal distributed load by ndli

pr pressure load

pr *region load_curve amplitude*

where

load_curve	is a load curve number or zero
amplitude	is an amplitude factor

Remarks

Pressure is a scalar quantity applied to a face of an element. A positive pressure acts on a face in the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

direction opposite the positive normal of the face.

All faces within the specified region are assigned the same pressure condition. When a load curve accompanies the condition, the pressure becomes time dependent. If the load curve number is zero, no load curve is specified and the pressure load is considered a constant.

True*Grid*® will, by default, select a positive normal direction for the face of an element. The positive normal direction can be specified using the **orpt** command.

pri pressure load by index progression

pri *progression load_curve amplitude*

where

load_curve	is a load curve number or zero
amplitude	is an amplitude factor

Remarks

This is the same as **pr** except that it applies to an index progression.

Example

A part is defined in Cartesian coordinates and the mesh is manipulated. The direction of the normals is defined by the **orpt** command. The pressure is assigned to the faces of the index progressions `-1 0 2 3; -1 0 -4;;` and `-1;;;` (**Figure 345**). The command file follows:

... definition of the mesh ...

```
orpt + 2 0 1.5
 c definition of normals,
 c the normals point toward
 c the point 2 0 1.5

pri  -1 0 2 3; -1 0 -4;;0 2800
 c pressure is assigned
 c to the faces of the index
```

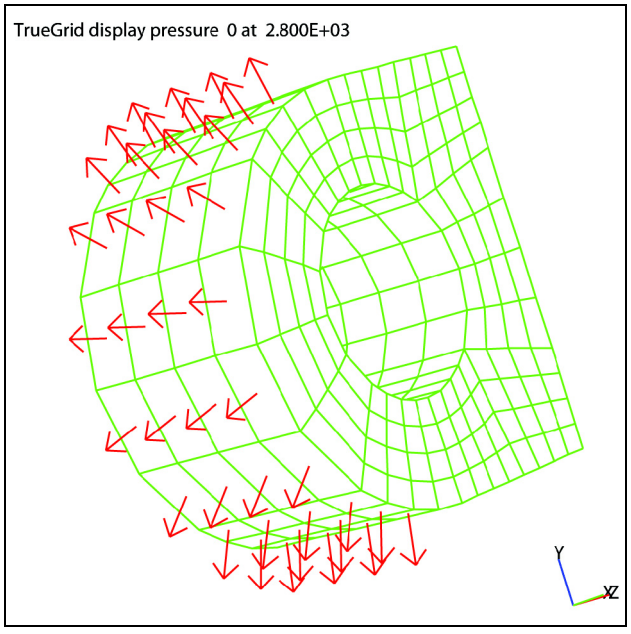


Figure 345 pressure by pri

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
 c progression
 c -1 0 2 3; -1 0 -4;;
 c by the null load curve
 c with amplitude 2800

pri  -1;;;0 2800
 c pressure is assigned
 c to the faces of the index
 c progression
 c -1;;;
 c by the null load curve
 c with amplitude 2800

merge

co pr 0   c display of pressure for the null load curve
```

pramp pressure amplitudes from a FORTRAN like expression

pramp = *fortran_expression*

where the *fortran_expression*
goes to the end of the record or is terminated by a semicolon, where the mesh variables **x**, **y**, and **z**, the pressure amplitude variable **pramp**, the mesh indices **i**, **j**, and **k**, and the temporary variables **t1, t2, t3** can be used in the expression, with the following options:

- integers, floating point, and exponential numbers as operands,
- parameters as operands,
- operators +, -, *, /, **, ^,
- parentheses,
- FORTRAN functions int, nint, abs, mod, sign, max, min, sqrt, exp, log, log10, sin, cos, tan, asin, acos, atan, atan2, sinh, cosh, where angles are measured in degrees,
- & at the end of a line continues the line to the next,
- uniform random number using the forms rand, rand(seed), rand(seed,mean)
- normal random number in the forms norm, norm(seed), norm(seed,mean),
- norm(seed,mean,sig)

  where seed is the random number seed, mean is the mean of the distribution, and sig is the standard deviation from the mean.

Remarks

Pressures are applied to the mesh using the **x**, **y**, **z**, **i**, **j**, and **k** values from each node in the mesh. The

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

expression can also include the variable **t1**, **t2**, **t3**, and **pramp**. The mesh arrays **t1**, **t2**, **t3**, and **pramp** can be used as temporary variables. Use the **dom** command to select the region of the mesh to apply this function. **pramp** can be assigned values many times using this command, with the final array of values being used to assign pressure amplitudes. The resulting pressure amplitudes are used only when the amplitudes in the **pr** or **pri** commands are zero. The amplitude is calculated at the 4 corner node points of a face and then averaged to form the pressure amplitude at the center of the face.

Example

A part is defined in Cartesian coordinates and the mesh is manipulated. The pressure with zero amplitude is assigned to the faces of the region `1 1 2 5 4 2` (**Figure 346**). Domain for the variable pressure is defined by the **dom** command on the same region. The variable pressure is defined by the **pramp=** command on the domain. The command file follows:

```
pr 1 1 2 5 4 2 0 0
 c pressure is assigned
 c to the region 1 1 2 5 4 2
 c by the null load curve 0
 c with amplitude 0
dom 1 1 2 5 4 2
 c region 1 1 2 5 4 2
 c is defined as a domain
 c for varying pressure
pramp= 1000 * x
 c variable pressure is
 c defined for faces
 c in the region 1 1 2 5 4 2
 c by expression 1000 * x
merge
co pr 0
 c display pressure for the
 c null load curve
```

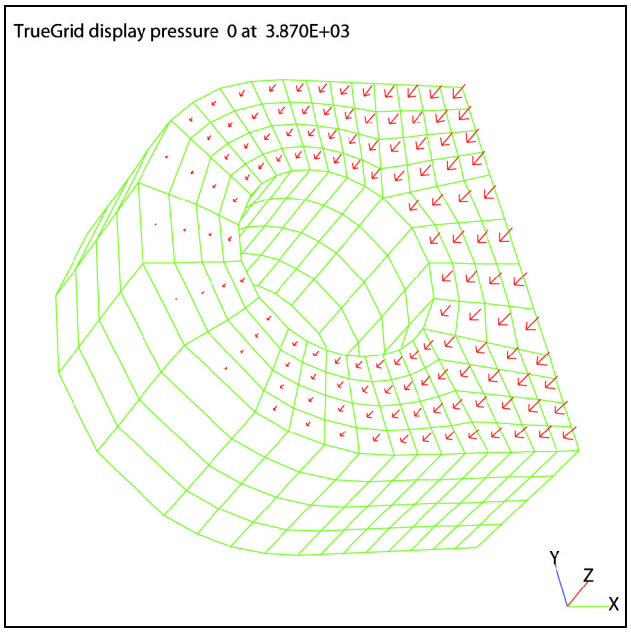


Figure 346 variable pressure by pramp

13. Boundary and Constraint Commands

This chapter describes boundary and constraint commands in the Part Phase. Boundary and constraint properties that are independent of the regions and index progressions of a particular part can be found in the Global chapter.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

b global nodal displacement and rotation constraints

b region *options* ;

where

options can be any number of the following:

sid *n*	for a set identification number
dx *init*	for x displacement
dy *init*	for y displacement
dz *init*	for z displacement
rx *init*	for rotation about the x axis
ry *init*	for rotation about the y axis
rz *init*	for rotation about the z axis

where

init is

0	to initialize to no constraint, or
1	to constrain.

Remarks

This command adds constraints to nodes of a region in the global coordinate system. Initially there are no constraints. Each **b** command modifies the constraints for the nodes of the region. Thus several commands may set different constraints for the same node. This has a cumulative effect. For example, you can remove degrees of freedom in the **x**-direction for nodes of an edge of the mesh. Then the constraint lists of all nodes along this edge are modified to reflect this constraint. Then you could place a displacement constraint in the **y**-direction on an adjoining edge of the mesh. The corner node where these two edges meet would then be supported in both the **x** and **y**-directions.

Several other commands can affect the constraints. For example, the **plane** command with the **symm** option for symmetry can add constraints if the symmetry plane is parallel to one of the coordinate planes.

In the Merge Phase, different nodes may be merged into one. The merged node inherits ALL of the constraints of the nodes which were merged into it. To view the different constraints in the model, use the **condition** command with the **dx**, **dy**, **dz**, **rx**, **ry**, or **rz** options while in the Merge Phase.

Sid specifies a set identification number so that the nodal constraints are written to the NASTRAN and NE/NASTRAN output using the SPC1 and SPCADD keywords. For ABAQUS output, the set identification number becomes the load set number used in abcload option of the **abaqstep** to associate the boundary condition with a step in the analysis.

Example

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The mesh is defined and manipulated. The boundary constraint is assigned to the nodes of the edge `1 1 1 5 1 1` with constrained displacement in **x**, **y** and **z**. The **y** and **z**-constraints are assigned to the nodes of the region `1 5 1 5 5 1`. The constrained displacement in the **z**-direction is displayed (**Figure 347**). The simplified command file follows:

```
block 1 3 5 7 9;1 3 5 7 9;-1;
      1 3 5 7 9;1 3 5 7 9; 0;
   c mesh definition
dei 1 2; 3 5; -1;
   c deletion
b 1 1 1 5 1 1 dx 1 dy 1 dz 1 ;
   c boundary constraint
   c  is assigned to edge
   c  1 1 1 5 1 1
   c  with constrained dx, dy
   c  and dz
b 1 5 1 5 5 1 dy 1 dz 1 ;
   c boundary constraint
   c  is assigned to edge
   c  1 5 1 5 5 1
   c  with constrained dy
   c  and dz
merge
co dz c display of dz
      c constraints
```

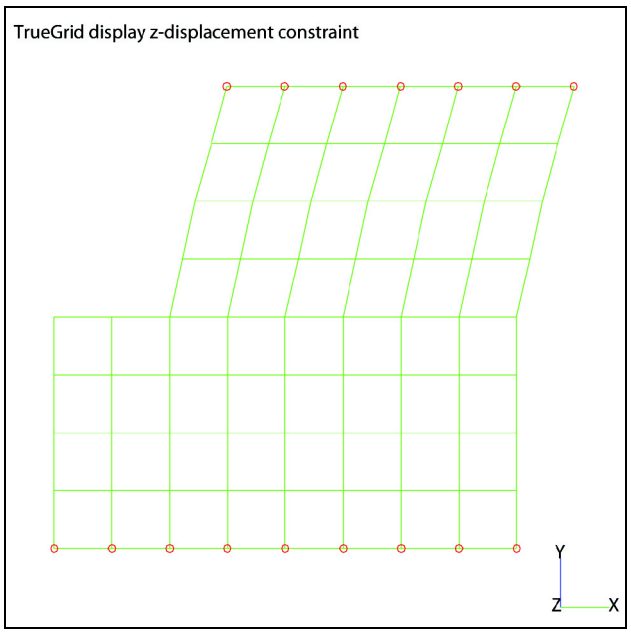


Figure 347 z-constraint

bi global nodal constraints, by progression

bi *progression options ;*

where

options can be any number of the following:

sid *n*	for a set identification number
dx *init*	for x displacement
dy *init*	for y displacement
dz *init*	for z displacement
rx *init*	for rotation about the x axis
ry *init*	for rotation about the y axis
rz *init*	for rotation about the z axis

where

init is

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

0 to initialize to no constraint, or
1 to constrain.

Remarks

The list of constraints is associated with each node of the index progression. See the remarks on **b** above.

cfc convective flow (CF3D) output boundary conditions

cfc *region id type parameters*

where the

type and *parameters* can be:

fv *vx vy vz*	for fixed velocity
ft *temperature*	for fixed temperature
fsp *species_# amplitude*	for fixed species
ol *pressure*	for an outlet
il *vx vy vz*	for an inlet
wall	for a wall with 0 velocity
ufl *amplitude*	for u-flux
vfl *amplitude*	for v-flux
wfl *amplitude*	for w-flux
tfl *temperature*	for temperature flux
spf *species_# amplitude*	for species flux
cb	for obstruction

Remarks

This command selects a region to apply any of the conditions associated with the CF3D command. There is also a merge phase version of this command to be used with an arbitrary set of faces. All conditions are applied to faces of linear brick elements.

Example

```
cfc 1 1 1 3 2 1 bndry_1 wall
```

This example has a k-face of the part across 2 regions in the i-direction, and across one region in the j-direction and assigned the wall condition. These faces are associated with bndry_1.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

cfci CF3D output boundary conditions by progression

cfci *progression id type parameters*

where the

type and *parameters* can be:

fv *vx vy vz*	for fixed velocity
ft *temperature*	for fixed temperature
fsp *species_# amplitude*	for fixed species
ol *pressure*	for an outlet
il *vx vy vz*	for an inlet
wall	for a wall with 0 velocity
ufl *amplitude*	for u-flux by index progression
vfl *amplitude*	for v-flux
wfl *amplitude*	for w-flux
tfl *temperature*	for temperature flux
spf *species_# amplitude*	for species flux
cb	for obstruction

Remarks

See **cfc** above.

Example

```
cfci -1 -2;-1 -2;; pr_2 ft -1.2
```

This example selects faces of a block and assigns a pressure. Its name is pr_2.

fbc FLUENT boundary conditions

fbc *region type zone*

where *type* can be

interior	
wall	
pr_inlet	pressure-inlet
inlet_ve	inlet-vent
intake_f	intake-fan
pr_outle	pressure-outlet
exhaust_	exhaust-fan

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

outlet_v	outlet-vent
symmetry	
per_shad	periodic-shadow
pr_far_f	pressure-far-field
velocity	velocity-inlet
periodic	
fan	
porous_j	porous-jump
radiator	
mass_flo	mass-flow-inlet
interfac	interface
outflow	
axis	

fbci FLUENT boundary conditions by index progression

fbci *progression type zone*

where *type* can be

interior	
wall	
pr_inlet	pressure-inlet
inlet_ve	inlet-vent
intake_f	intake-fan
pr_outle	pressure-outlet
exhaust_	exhaust-fan
outlet_v	outlet-vent
symmetry	
per_shad	periodic-shadow
pr_far_f	pressure-far-field
velocity	velocity-inlet
periodic	
fan	
porous_j	porous-jump
radiator	
mass_flo	mass-flow-inlet
interfac	interface
outflow	
axis	

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

jt assign a node to a numbered joint

jt *joint_# local_node_# options ;*

where

joint_# is the number of a joint defined by **jd**, page 895

local_node_# is the joint's local node number, and

options is a list of any of the following options:

n *i j k*	assign a vertex of the mesh to be a joint node
p *x y z material_#*	create a new rigid body node in Cartesian coordinates and use it as a joint node where the material number is that of a rigid material
cy *rho theta z material_#*	create a new rigid body node in cylindrical coordinates and use it as a joint node where the material number is that of a rigid material
s *rho theta phi material_#*	create a new rigid body node in spherical coordinates and use it as a joint node where the material number is that of a rigid material
inc *increment*	increment joint number for each duplicate part
minc *incrment*	increment material number for each duplicate part
llinc *increment*	joint local node number local replication increment
glinc *increment*	joint local node number global replication increment
v *x_offset y_offset z_offset*	move the newly created joint node

Remarks

First define the joint with the **jd** command, page 895. A warning message will result if the joint is not defined before it is referenced by this command.

The **p**, **cy**, and **s** options create a new node and assign the new nodes to an existing joint. The **p** option defines the node in Cartesian coordinates. The **cy** specifies the coordinates in cylindrical coordinates, and the **s** option in spherical coordinates.

The local node number is used with joints, such as **cj** (see page 895) where each node in the joint is numbered. When the joint type is simply one where nodes share degrees of freedom (**dx**, **dy**, **dz**, **rx**, **ry**, and **rz** constraints in the **jd** command), the local node numbers are just the indices into the list of nodes associated with the joint definition. Up to 16 nodes can be constrained together in one joint definition.

Joint number increments work much like material number increments. See page 452 for more information.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

The joint number 1 is defined as a spherical joint. At first Part 1 is created by the **block** command and the node with reduced indices 3 3 1 is assigned to joint 1 as local node 1. Then Part 2 is created and the node with reduced indices 1 1 1 is assigned to joint 1 as local node 2 (**Figure 348**). The command file follows:

```
jd 1 sj pnlt 6 ;
  c spherical joint is defined
block 1 3 5;1 3 5;-1;
     1 3 5;1 3 5;0;
  c Part 1 is defined
jt 1 1 n 3 3 1 ;
  c node with reduced
  c indices 3 3 1
  c is assigned to joint 1
  c for local node 1
block 1 3 5;1 3 5;-1;
     5 7 9;5 7 9;0;
  c Part 2 is defined
jt 1 2 n 1 1 1 ;
  c node with reduced
  c indices 1 1 1
  c is assigned to joint 1
  c for local node 2
merge
co jt 1   c display of joint 1
```

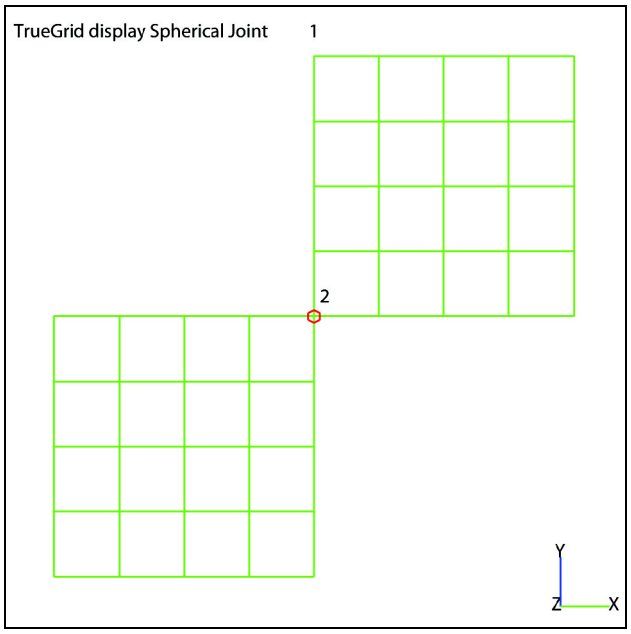


Figure 348 cylindrical joint is in between 2 parts

The same physical effect as in the previous example (cylindrical joint allows independent rotations and constrains displacements) can be achieved by sharing translational degrees of freedom between the local nodes. So the joint number 1 is defined as a joint with shared constraints. At first, Part 1 is created by the **block** command and the node with reduced indices 3 3 1 is assigned to joint 1 as local node 1. Then Part 2 is created and the node with reduced indices 1 1 1 is assigned to joint 1 as local node 2 (**Figure 348**). The command file follows:

```
jd 1 dx dy dz ; c joint with shared degrees of freedom
                c is defined
block 1 3 5;1 3 5;-1; 1 3 5;1 3 5;0;    c Part 1 is defined
jt 1 1 n 3 3 1 ;  c node with reduced indices 3 3 1 is assigned
                  c to joint 1 for local node 1
block 1 3 5;1 3 5;-1;5 7 9;5 7 9;0;     c Part 2 is defined
jt 1 2 n 1 1 1 ;    c node with reduced indices 1 1 1 is assigned
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
                    c to joint 1 for local node 2
merge
co jt 1    c display of joint 1
```

il identifies an inlet for fluid flow.

il *region*

Example

The mesh is defined and shaped. The **il** command specifies faces of elements from the region `1 1 2 2 2 2` as an inlet for the fluid flow (**Figure 349**). The simplified command file follows:

```
cylinder
 1 6;1 37;1 15;1 4;0 360;1 7;
 c mesh definition
il  1 1 2 2 2 2
 c faces of region 1 1 2 2 2 2
 c are defined as inlet
merge
co il      c display of inlet
```

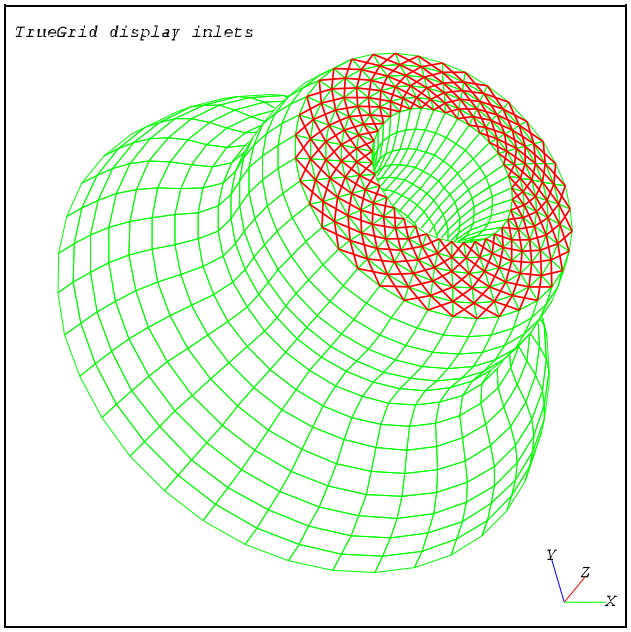


Figure 349 element faces with inlet

ili identifies an inlet for fluid flow, by index progression

ili *progression*

Remarks

This command behaves the same as the previous command over multiple regions. See **il**.

kiva3bc set boundary conditions for KIVA3v

kiva3bc *region type value*

where *type* and *value* can be

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

bc *value* for Boundary condition (faces only)
where *value* can be
1 for moving
2 for solid
3 for axis
4 for fluid
5 for periodic front
6 for periodic derriere
7 for specified velocity inflow
8 for continuative outflow
9 for pressure inflow
10 for pressure outflow

idface *value* for moving vertices (any region)

fv *value* for vertex flags (any region)
where *value* can be
0 for inactive
1 for other (fluid)
2 for piston face
3 for bowl
4 for squish
5 for dome
6 for cylinder

f *value* for cell flag (solid elements only)

kiva3bci set boundary conditions for KIVA3v

kiva3bci *progression type value*
where *type* and *value* can be
bc *value* for Boundary condition (faces only)
where *value* can be
1 for moving
2 for solid
3 for axis
4 for fluid
5 for periodic front
6 for periodic derriere

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

7 for specified velocity inflow
8 for continuative outflow
9 for pressure inflow
10 for pressure outflow

idface *value* for moving vertices (any region)

fv *value* for vertex flags (any region)
where *value* can be
0 for inactive
1 for other (fluid)
2 for piston face
3 for bowl
4 for squish
5 for dome
6 for cylinder

f *value* for cell flag (solid elements only)

kivabc boundary conditions for kiva4 output format

kivabc *region region_id radiation_id type*
where *type* can be
moving for moving piston
movingb1 for moving bottom face of 1st valve
movingt1 for moving top face of 1st valve
movingb2 for moving bottom face of 2nd valve
movingt2 for moving top face of 2nd valve
movingb3 for moving bottom face of 3rd valve
movingt3 for moving top face of 3rd valve
movingb4 for moving bottom face of 4th valve
movingt4 for moving top face of 4th valve
solid for a face of a solid
solidh for a solid face of a cylinder head
axis for a face on the axis
fluid for a fluid face (default)
inflow for an inlet
outflow for an outlet
presin for pressure inflow

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

presout for pressure outflow
userdef *value* for user defined condition

kivabci boundary conditions for kiva4 output format

kivabci *progression region_id radiation_id type*
where *type* can be
moving for moving piston
movingb1 for moving bottom face of 1st valve
movingt1 for moving top face of 1st valve
movingb2 for moving bottom face of 2nd valve
movingt2 for moving top face of 2nd valve
movingb3 for moving bottom face of 3rd valve
movingt3 for moving top face of 3rd valve
movingb4 for moving bottom face of 4th valve
movingt4 for moving top face of 4th valve
solid for a face of a solid
solidh for a solid face of a cylinder head
axis for a face on the axis
fluid for a fluid face (default)
inflow for an inlet
outflow for an outlet
presin for pressure inflow
presout for pressure outflow
userdef *value* for user defined condition

lb local nodal displacement and rotation constraints

lb *region system options ;*
where
system is the name of a local coordinate system defined by **lsys**, and
options is a list of any of the following:
dx *init* for x displacement,
dy *init* for y displacement,
dz *init* for z displacement,
rx *init* for rotation about the x axis,
ry *init* for rotation about the y axis, or
rz *init* for rotation about the z axis

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

where
init is
0 to initialize to no constraint, or
1 to constrain.

Remarks

Use this command to set constraints on nodes that cannot be set using the **b** or **bi** commands because they are restricted to the global coordinate system. Care is needed not to over specify the constraints on a node. No warnings are given if a node is over constrained. Use the **lsys** command to define the local coordinate system.

lbi local nodal boundary constraints, by progression

lbi *progression system options*

where
system is the name of a local coordinate system defined by **lsys**, and
options is a list of any of the following:
dx *init* for x displacement,
dy *init* for y displacement,
dz *init* for z displacement,
rx *init* for rotation about the x axis,
ry *init* for rotation about the y axis, or
rz *init* for rotation about the z axis
where
init is
0 to initialize to no constraint, or
1 to constrain.

Remarks

Use this command to set constraints on nodes that cannot be set using the **b** or **bi** commands because they are restricted to the global coordinate system. Care is needed not to over specify the constraints on a node. No warnings are given if a node is over constrained. Use the **lsys** command to define the local coordinate system.

Example

```
block 1 10;1 10;1 10;1 10;1 10;1 10;
 c mesh definition
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
mbi ; -2; -2; z  2
 c move the edge ;-2;-2; 2 units in z-direction
lsys 1 rx [atan2(2,10)] ;
 c definition of local coordinate system 1
 c rotated around x-axis for angle atan2(2,10)
lbi ;-2; ;1 dy 1 ;
 c the faces of region ;-2;; are constrained in dy
 c displacement in local coordinate system 1
merge
```

namreg name a region for the TASCFLOW output file

namereg *region name_of_region*

Remarks

The TASCFLOW interface supports named regions. These regions are specified using the **namreg** command. You can also create a blocked region by assigning a material type 2 to the region using the **mt** command.

namregi name regions for the TASCFLOW output file

namregi *progression name_of_region*

nr non-reflecting boundary

nr *region*

nri non-reflecting boundaries

nri *progression*

ol face outlet for fluid flow

ol *region*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

The mesh is defined and shaped. The **ol** command specifies faces of elements from the region `1 1 1 2 2 1` as an outlet for the fluid flow (**Figure 350**). The simplified command file follows:

```
cylinder
 1 6;1 37;1 15;1 4;0 360;1 7;
 c mesh definition
ol  1 1 1 2 2 1
 c faces of region 1 1 1 2 2 1
 c are defined as outlet
merge
co ol      c display of outlet
```

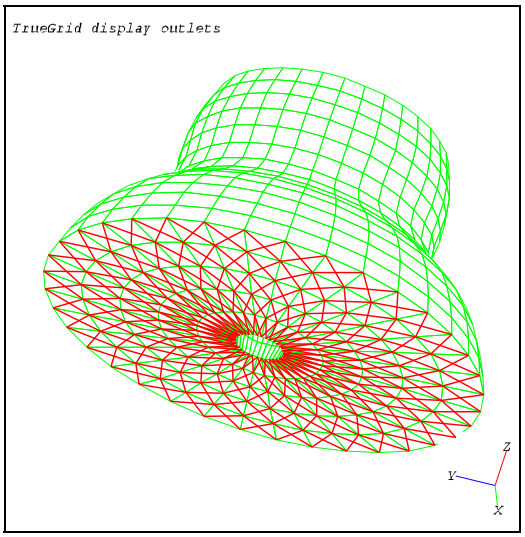


Figure 350 outlet

oli identifies faces of the mesh as an outlet for fluid flow

oli *progression*

Remarks

See **ol**.

reg select a region for the REFLEQS boundary condition

reg *region face type*

where

the *face* can be:

n	for the north face,
s	for the south face,
e	for the east face,
w	for the west face,
l	for the low face, or
h	for the high face, and

the *type* can be:

w	for wall,
p	for fixed pressure,
m	for constant mass inflow w/ momentum,

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

d	for constant mass inflow w/o momentum, or
s	for symmetry.

regi select regions for the REFLEQS boundary condition

regi *progression face type*

where

the *face* can be:

n	for the north face,
s	for the south face,
e	for the east face,
w	for the west face,
l	for the low face, or
h	for the high face, and

the *type* can be:

w	for wall,
p	for fixed pressure,
m	for constant mass inflow w/ momentum,
d	for constant mass inflow w/o momentum, or
s	for symmetry.

sfb locally constrain face nodes

sfb *region type flow_direction option_1 option_2 option_3 ;*

where *type* must be one of

mesh or

surface,

flow_direction must be one of

none	if the constraints requires no flow direction,
i	if the flow direction corresponds to the i-direction,
j	if the flow direction corresponds to the j-direction,
k	if the flow direction corresponds to the k-direction, or
coor *x y z*	to supply the flow direction vector,

option_1 (for **none** only) must be one of

t	for move only in the normal direction, or
n	for move only in the tangent plane

option_2 (for edge or vertex only) must be one of

i	extract normal direction from the i-face of the edge/vertex

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

j extract normal direction from the j-face of the edge/vertex
k extract normal direction from the k-face of the edge/vertex

option_3 (not for **none**) can be any of

dx for x-displacement,
dy for y-displacement,
dz for z-displacement,
rx for rotation about the x-axis,
ry for rotation about the y-axis, or
rz for rotation about the z-axis

followed by a value of

0 to initialize to no constraint, or
1 to constrain.

Remarks

First, the normal to the mesh or surface which formed the mesh is constructed, for each node in the region. This direction becomes the local z-axis. This is sufficient for some problems, so no flow direction is needed to construct a complete local coordinate system.

When a full local coordinate system is needed to apply boundary constraints in a local x or y-direction, then a second direction called the flow-direction, corresponding to the local x-axis, must be specified. There are several options. A mesh line can be used to select the direction, or a vector can be specified.

The **sfb** command can be applied to an edge or a single vertex of the mesh. When a face of the mesh is constrained by this command, the z-axis of the local coordinate system is taken from the normal of the mesh or surface (see the parameter *type* in the above). But when an edge or a vertex is selected as the region or index progression, additional information is required to choose a normal direction.

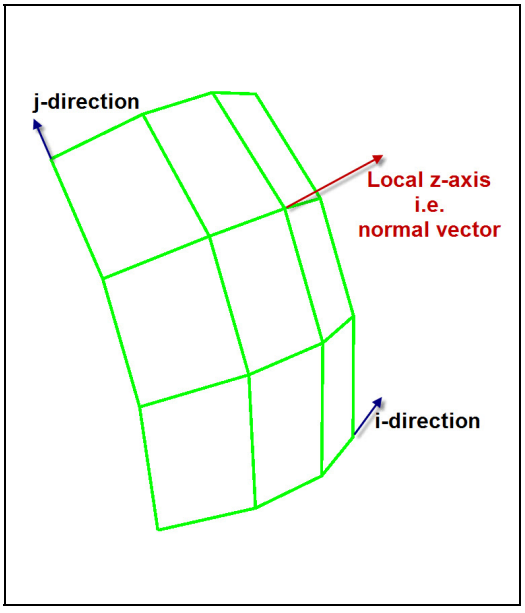


Figure 351 Local z-axis only

Examples

In this example, the nodes are only allowed to move in the direction of the normal vector. A full local coordinate system is not needed so a flow-direction in the tangent plane was not selected.

```
sfb 1 1 1 2 2 1 mesh none t ;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

In this next example, a flow-direction (local x-direction) is specified because the nodes are constrained in the flow-direction. Note that the local y-direction is implied but not used in this case. Also note that the normal (local z-axis) is determined from the surface of projection (a sphere) instead of approximating it from the neighboring nodes.

```
sfb 1 1 1 2 2 1 surface j dx 1;
```

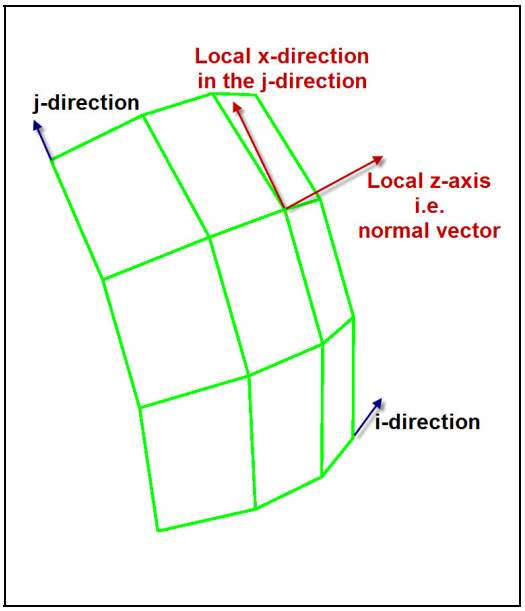


Figure 352 Full local coordinate system

Additional information is needed if nodal constraints relative to a local coordinate system is required along an edge of the mesh. This is a problem because the edge is likely to be the result of projections to two surfaces. Which one is to be used for the local z-axis? In the special case that an edge was chosen, the you must choose the type of face (i, j, or k) to be used to extract a normal direction.

```
sfb 2 1 2 2 2 2 surface j i dy 1 ;
```

This is complicated and the way to use this command is by way of the dialogue box. In this example, the i-face is used to extract the normal direction.

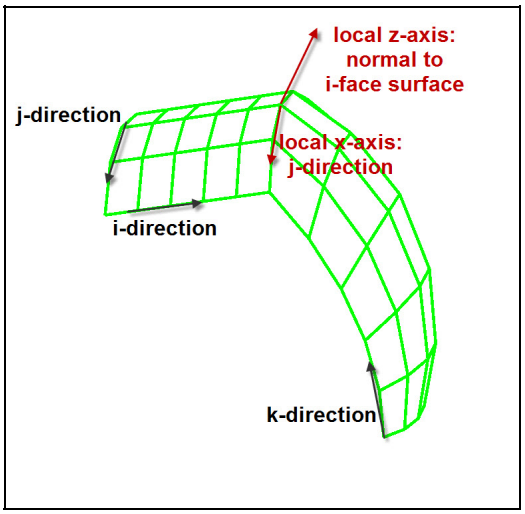


Figure 353 Local system for an edge

sfbi locally constrain face nodes by progression

sfbi *progression type flow_direction option_1 option_2 option_3 ;*

where *type* must be one of

mesh or

surface,

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

flow_direction must be one of

none	if the constraints requires no flow direction,
i	if the flow direction corresponds to the i-direction,
j	if the flow direction corresponds to the j-direction,
k	if the flow direction corresponds to the k-direction, or
coor *x y z*	to supply the flow direction vector,

option_1 (for **none** only) must be one of

t	for move only in the normal direction, or
n	for move only in the tangent plane

option_2 (for edge or vertex only) must be one of

i	extract normal direction from the i-face of the edge/vertex
j	extract normal direction from the j-face of the edge/vertex
k	extract normal direction from the k-face of the edge/vertex

option_3 (not for **none**) can be any of

dx	for x-displacement,
dy	for y-displacement,
dz	for z-displacement,
rx	for rotation about the x-axis,
ry	for rotation about the y-axis, or
rz	for rotation about the z-axis

followed by a value of

0	to initialize to no constraint, or
1	to constrain.

Remarks

See the remarks in **sfb** above.

sw assign nodes that may impact a stone wall

sw *region stone_wall_#*

Remarks

Set the properties of a stone wall using the **plane** command. Nodes are not automatically selected based on their proximity to the plane. The nodes must be selected using the **sw** or **swi** command.

swi assign nodes that may impact a stone wall

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

swi *progression stone_wall_#*

Remarks

Set the properties of a stone wall using the **plane** command. Nodes are not automatically selected based on their proximity to the plane. The nodes must be selected using the **sw** or **swi** command.

syf assign faces to a numbered symmetry plane with failure

syf *region symmetry_plane_# failure*

Remarks

Set the properties of a symmetry plane with failure using the **plane** command. Nodes are not automatically selected based on their proximity to the plane. The nodes must be selected using the **syf** or **syfi** command.

syfi assign faces to a numbered symmetry plane with failure

syfi *progression symmetry_plane_# failure*

Remarks

Set the properties of a symmetry plane with failure using the **plane** command. Nodes are not automatically selected based on their proximity to the plane. The nodes must be selected using the **syf** or **syfi** command.

trp create tracer particles for Lsdyna

trp *tracking list_options ;*

where

tracking can be **fixed** or **free** and

an *option_list* may consist of one of the following:

time *start_time*,

point *x0 y0 z0*, or

lnpt *x1 y1 z1 x2 y2 z2 #_tracers*.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

14. Radiation and Temperature Commands

These commands let you set various boundary conditions related to radiation and temperature. See also the radiation and temperature commands in the merge phase.

Some of these boundary conditions are directional. They may refer to the outward normal direction at a surface. This normal direction is oriented by a right-hand rule based on the node numbering. You usually will want to specify the directions with the **orpt** command.

bf bulk fluid

bf *region id_# load amplitude a b*

where

id_#	**bfd** bulk fluid identification number
load	load curve number
amplitude	multiplier of the load curve
a	exponent a
b	exponent b

Remarks

Use this command to identify those faces (surfaces) which are to be part of the bulk fluid (node) calculation.

Use the **orpt** command to orient the faces as desired.

Use the **co** command with the **bf** option to display the bulk fluid faces in the merge phase.

bfi bulk fluid by index progression

bfi *progression id_# load amplitude a b*

where

id_#	**bfd** bulk fluid identification number
load	load curve number
amplitude	multiplier of the load curve
a	exponent a
b	exponent b

Remarks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

See the **bf** command for remarks.

cv boundary convection

cv *region load_curve$_1$ amplitude$_1$ load_curve$_2$ amplitude$_2$ exponent*

where

load_curve$_1$	first load curve number or zero,
amplitude$_1$	amplitude factor for the first load curve,
load_curve$_2$	second load curve number or zero,
amplitude$_2$	amplitude factor for the second load curve, and
exponent	exponent.

Remarks

First use the **orpt** command to specify the surface orientation; that is, how to orient the normal vector.

A zero load curve number means that the condition is constant in time. If a curve is specified which has not been defined, a warning message will be issued.

cvi boundary convection

cvi *progression load_curve$_1$ amplitude$_1$ load_curve$_2$ amplitude$_2$ exponent*

where

load_curve$_1$	first load curve number or zero,
amplitude$_1$	amplitude factor for the first load curve,
load_curve$_2$	second load curve number or zero,
amplitude$_2$	amplitude factor for the second load curve, and
exponent	exponent.

Remarks

See the remarks on **cv**, page 366.

vcv boundary convection with functional amplitudes

vcv *region load_curve$_1$ amplitude$_1$ load_curve$_2$ amplitude$_2$ exponent*

where

load_curve$_1$	is the first load curve number or zero,
amplitude$_1$;	is the amplitude expression for the first load curve,
load_curve$_2$	is the second load curve number or zero,

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

amplitude$_2$; is the amplitude expression for the second load curve, and
exponent ; is the exponent expression.

Remarks

Each expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions. The values of these variables are the averages of the corresponding coordinates and indices of the nodes that define the polygon. See the remarks on **cv**.

vcvi boundary convection with functional amplitudes

vcvi *progression load_curve*$_1$ *amplitude*$_1$ *load_curve*$_2$ *amplitude*$_2$ *exponent*

where

load_curve$_1$	is the first load curve number or zero,
amplitude$_1$	is the amplitude expression for the first load curve,
load_curve$_2$	is the second load curve number or zero,
amplitude$_2$	is the amplitude expression for the second load curve, and
exponent	is the exponent expression.

Remarks

Each expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions. The values of these variables are the averages of the corresponding coordinates and indices of the nodes that define the polygon.

See the remarks on **cv**.

cvt convection thermal loads

cvt *region coefficient temperature*

where

coefficient	film coefficient
temperature	temperature near convection

Remarks

First use the **orpt** command to specify the surface orientation; that is, how to orient the outward normal vector.

This command is used to create convection thermal loads for ANSYS. The first parameter is the film *coefficient*. This is followed by the *temperature* near convection. This command will create the EP

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

cards for the ANSYS input file.

cvti convection thermal loads

cvti *progression coefficient temperature*
where
coefficient film coefficient
temperature temperature near convection

Remarks

See the remarks on **cvt** above.

fl prescribed boundary flux

fl *region load_curve_# amplitude*
where
load_curve_# a load curve number
amplitude amplitude constant

Remarks

First use the **orpt** command to specify the surface orientation; that is, how to orient the outward normal vector.

fli prescribed boundary flux

fli *progression load_curve_# amplitude*
where
load_curve_# a load curve number
amplitude amplitude constant

Remarks

See the remarks on **fl**.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

vfl prescribed boundary flux with functional amplitude

vfl *region load_curve_# amplitude* ;

where

load_curve_#	a load curve number
amplitude	amplitude expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions. See the remarks on **fl**.

vfli prescribed boundary flux with functional amplitude

vfli *progression load_curve_# amplitude* ;

where

load_curve_#	a load curve number
amplitude	amplitude expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions.

See the remarks on **fl**.

ft prescribed temperature

ft *region load_curve_# temperature*

where

load_curve_#	a load curve number
temperature	temperature constant

Remarks

This specifies a time-dependent temperature boundary condition on the region. It is assumed that the temperature used by the appropriate simulation code will be the product of the temperature and the amplitude of the load curve at the appropriate time in the simulation.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

fti prescribed temperature by progression

fti *progression load_curve_# temperature*

where

load_curve_#	a load curve number
temperature	temperature constant

Remarks

This specifies a time-dependent temperature boundary condition on the regions. It is assumed that the temperature used by the appropriate simulation code will be the product of the temperature and the amplitude of the load curve at the appropriate time in the simulation.

vft functional prescribed temperature

vft *region load_curve_# temperature* ;

where

load_curve_#	a load curve number or 0
temperature	temperature expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions. This specifies a time-dependent temperature boundary condition on the regions. It is assumed that the temperature used by the appropriate simulation code will be the product of the temperature, derived from the temperature expression in this command, and the amplitude of the load curve at the appropriate time in the simulation.

vfti functional prescribed temperature by progression

vfti *progression load_curve_# temperature ;*

where

load_curve_#	a load curve number or 0
temperature	temperature expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions. This specifies a time-dependent temperature boundary condition on the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

regions. It is assumed that the temperature used by the appropriate simulation code will be the product of the temperature, derived from the temperature expression in this command, and the amplitude of the load curve at the appropriate time in the simulation.

hfl specify flows and fluxes

hfl *region label rate*

where

label can be any one of:

heat for heat flow,
flow for fluid flow,
amps for current, or
flux for magnetic flux

rate constant

Remarks

First use the **orpt** command to specify the surface orientation; that is, how to orient the outward normal vector.

hfli specify flows and fluxes, by index progression

hfli *region label rate*

where

label can be any one of:

heat for heat flow,
flow for fluid flow,
amps for current, or
flux for magnetic flux

rate constant

Remarks

First use the **orpt** command to specify the surface orientation; that is, to orient the outward normal vector.

inizone initial conditions for the REFLEQS option

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

inizone *region var_name arr_name*

where

var_name can be

nvu for i-velocity component,
nvv for j-velocity component,
nvw for k-velocity component,
nvpp for pressure correction,
nvk1 for kinetic energy of turbulence,
nvk2 for kinetic energy of turbulence,
nvd1 for dissipation of turbulence energy,
nvd2 for dissipation of turbulence energy,
nvh for stagnation enthalpy,
nvrx for x-direction composite radiation flux,
nvry for y-direction composite radiation flux,
nvrz for z-direction composite radiation flux,
narho for fluid density,
nap for pressure,
nat for fluid temperature, or
len for mixing length scale

arr_name can be one of the holding array names
vi, **va**, **vb**, **vc**, **vd**, **ve**, **vf**, and **vu**

inizonei initial conditions for the REFLEQS option, by progression

inizonei *progression var_name arr_name*

where

var_name can be

nvu for i-velocity component
nvv for j-velocity component
nvw for k-velocity component
nvpp for pressure correction
nvk1 for kinetic energy of turbulence
nvk2 for kinetic energy of turbulence
nvd1 for dissipation of turbulence energy
nvd2 for dissipation of turbulence energy
nvh for stagnation enthalpy
nvrx for x-direction composite radiation flux
nvry for y-direction composite radiation flux
nvrz for z-direction composite radiation flux

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

narho for fluid density
nap for pressure
nat for fluid temperature
len for mixing length scale

arr_name can be one of the holding array names
vi, **va**, **vb**, **vc**, **vd**, **ve**, **vf**, and **vu**

setsor set REFLEQS source terms

setsor *region var_name coefficient value*

where

var_name can be

nvu for i-velocity component,
nvv for j-velocity component,
nvw for k-velocity component,
nvpp for pressure correction,
nvk1 for kinetic energy of turbulence,
nvk2 for kinetic energy of turbulence,
nvd1 for dissipation of turbulence energy,
nvd2 for dissipation of turbulence energy,
nvh for stagnation enthalpy,
nvrx for x-direction composite radiation flux,
nvry for y-direction composite radiation flux,
nvrz for z-direction composite radiation flux,
narho for fluid density,
nap for pressure,
nat for fluid temperature, or
len for mixing length scale.

Remarks

This command is to be used in conjunction with the REFLEQS output format. It enables you to define the source terms in the transport (conservation) equations which are solved by the analysis package.

setsori set REFLEQS source terms, by index progression

setsori *progression var_name coefficient value*

where

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

var_name can be

nvu for i-velocity component
nvv for j-velocity component
nvw for k-velocity component
nvpp for pressure correction
nvk1 for kinetic energy of turbulence
nvk2 for kinetic energy of turbulence
nvd1 for dissipation of turbulence energy
nvd2 for dissipation of turbulence energy
nvh for stagnation enthalpy
nvrx for x-direction composite radiation flux
nvry for y-direction composite radiation flux
nvrz for z-direction composite radiation flux
narho for fluid density
nap for pressure
nat for fluid temperature
len for mixing length scale

rb prescribed radiation boundary condition

rb *region load_curve$_1$ amplitude$_1$ load_curve$_2$ amplitude$_2$*

where

load_curve$_1$	a load curve number
amplitude$_1$	amplitude constant
load_curve$_2$	a load curve number
amplitude$_2$	amplitude constant

Remarks

First use the **orpt** command to specify the surface orientation; that is, how to orient the outward normal vector. If a load curve number is specified as zero, then the condition is constant in time.

rbi prescribed radiation boundary condition, by progression

rbi *progression load_curve$_1$ amplitude$_1$ load_curve$_2$ amplitude$_2$*

where

load_curve$_1$	a load curve number
amplitude$_1$	amplitude constant

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

load_curve$_2$	a load curve number
amplitude$_2$	amplitude constant

Remarks

See the remarks on **rb** above.

vrb prescribed radiation boundary w/ functional amplitudes

vrb *region load_curve*$_1$ *amplitude*$_1$ *; load_curve*$_2$ *amplitude*$_2$ *;*

where

load_curve$_1$	a load curve number
amplitude$_1$	amplitude expression
load_curve$_2$	a load curve number
amplitude$_2$	amplitude expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions. See the remarks on **rb** above.

vrbi prescribed radiation boundary, by progression w/ functional amplitudes

vrbi *progression load_curve*$_1$ *amplitude*$_1$ *load_curve*$_2$ *amplitude*$_2$

where

load_curve$_1$	a load curve number
amplitude$_1$	amplitude expression
load_curve$_2$	a load curve number
amplitude$_2$	amplitude expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions.

See the remarks on **rb** above.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

re radiation enclosure

re *region emissivity_load_curve_# obstruction_flag*
or
re *region 0 temperature obstruction_flag*

where

emissivity_load_curve	load curve number
temperature	constant
obstruction flag is:	
yes	to include surface obstruction calculations
no	to not include surface obstruction calculations

Remarks

First use the **orpt** command to specify the surface orientation; that is, how to orient the outward normal vector.

This command generates enclosure radiation data for TOPAZ3D. Use the **emissivity** and **rband** commands to specify the emissivity and wavelength breakpoint tables associated with the enclosure radiation data. For more details, see the TOPAZ3D manual.

rei radiation enclosure by index progression

rei *progression emissivity_load_curve_# obstruction_flag*
or
rei *progression 0 temperature obstruction_flag*

where

emissivity_load_curve	load curve number
temperature	constant
obstruction flag is:	
yes	to include surface obstruction calculations
no	not to include surface obstruction calculations

Remarks

First use the **orpt** command to specify the surface orientation; that is, how to choose the outward normal vector.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

te constant nodal temperature

te *region temperature*
where *temperature* is the constant temperature.

Remarks

Use the temp to set the majority of the part to a constant nodal temperature. Use this command to set the exceptional regions.

tei constant nodal temperature

tei *progression temperature*
where *temperature* is the constant temperature.

Remarks

Use the temp to set the majority of the part to a constant nodal temperature. Use this command to set the exceptional regions.

temp part default constant nodal temperature

temp *temperature*
where *temperature* is the constant nodal temperature.

Remarks

This command works with the **te** and **tei** commands. You can set the constant temperature to that which is needed for the majority of the part. Then use the **te** or **tei** command to change the constant temperature for the exceptional regions.

tepro variable nodal temperature profile

tepro *region load_curve_# scale_expr ; base_expr ;*
where
load_curve_# is the load curve number or zero,
scale_expr is a FORTRAN expression for the scale, and

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

base_expr is a FORTRAN expression for the base temperature.

Remarks

Both the base temperature and load curve scaling factor can be functions of the **x**, **y**, and **z**-coordinates of the node and the **i**, **j**, and **k**-indices of the node. This command is used for input to DYNA3D, LS-DYNA, and NIKE3D.

tm initial temperature condition

tm *region temperature*
where
temperature temperature constant

tmi initial temperature condition by index progression

tmi *progression temperature*
where
temperature temperature constant

vtm initial temperature w/ functional temp

vtm *region temperature* ;
where
temperature temperature expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions.

vtmi initial temperature by index progression w/ functional temp

vtmi *progression temperature* ;
where
temperature temperature expression

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions.

vhg volumetric heat generation

vhg *region load_curve_# amplitude*

where

load_curve_#	a load curve number
amplitude	amplitude constant

vhgi volumetric heat generation by index progression

vhgi *progression load_curve_# amplitude*

where

load_curve_#	a load curve number
amplitude	amplitude constant

vvhg volumetric heat generation w/ functional amplitude

vvhg *region load_curve_# amplitude* ;

where

load_curve_#	a load curve number
amplitude	amplitude expression

Remarks

The expression can be any valid FORTRAN like expression with x, y, z, i, j, and k and valid parameters in the expressions.

15. Electric Condition Commands

efl electric flux boundary condition

efl *region value_of_flux*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

This command produces four-node polygons with an assigned constant flux, one polygon for each face within the region.

efli electric flux boundary condition by index progression

efli *progression value_of_flux*

Remarks

This command produces four-node polygons with an assigned constant flux, one polygon for each face within the regions given by the specified progression.

mp constant magnetic potential

mp *region potential*

mpi constant magnetic potential

mpi *progression potential*

v electrostatic potential boundary condition

v *region potential*

Remarks

The specified nodal electrostatic potential is assigned for all nodes in the specified region.

vi electrostatic potential boundary condition

vi *progression potential*

Remarks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The specified nodal electrostatic potential is assigned for all nodes in the specified index progression.

16. Springs, Dampers, and Point Masses

npm creates a node with a point mass

npm *mp_node_# x y z mass options ;*

where

mp_node_# is the node number which is created,
x y z are the coordinates of the point mass,
mass is the assigned mass, and
options can be :

inc *increment*	for the increment in the node number under replication,
dx	for no nodal displacement in the x-direction,
dy	for no nodal displacement in the y-direction,
dz	for no nodal displacement in the z-direction,
rx	for no nodal rotations about the x-axis,
ry	for no nodal rotations about the y-axis,
rz	for no nodal rotations about the z-axis,
mdx	for no mass displacement in the x-direction,
mdy	for no mass displacement in the y-direction,
mdz	for no mass displacement in the z-direction,
mrx	for no mass rotation about the x-axis,
mry	for no mass rotation about the y-axis,
mrz	for no mass rotation about the z-axis,
ixx *mom*	to specify the moment of inertia about the x-axis,
iyy *mom*	to specify the moment of inertia about the y-axis,
izz *mom*	to specify the moment of inertia about the z-axis,
pdamp *alpha*	for the proportional damping factor (ABAQUS), and/or
cdamp *fraction*	for the fraction of critical damping (ABAQUS).

Remarks

This new node can be attached to the mesh by creating a spring using the **spring** command in the Part or Merge Phase, or by creating a beam in the Merge Phase using the **bm** command. This new node can also be attached to the rest of the mesh in the Merge Phase by merging it to a neighboring node (see **t**, **tp**, **stp**, **bptol**, and **ptol**). This is distinguished from the assignment of a mass to a vertex of the present part. The latter can be done using the **pm** command. In both cases, the point mass is replicated or transformed along with the present part (see **lrep**, **grep**, and **pslv**). In order to create a new node and assign it a point mass such that it does not get replicated or transformed along with the present part, then use the **npm** command in the Merge Phase. In order to assign a point mass to any node in the mesh such

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

that it does not get replicated or transformed along with the present part, use the **pm** command in the Merge Phase.

pm point mass to a vertex of the present part

pm *region node_mass options ;*

where

node_mass is the assigned mass, and

options can be :

mdx	for no mass displacement in the x-direction,
mdy	for no mass displacement in the y-direction,
mdz	for no mass displacement in the z-direction,
mrx	for no mass rotations about the x-axis,
mry	for no mass rotations about the y-axis,
mrz	for no mass rotations about the z-axis,
ixx *mom*	to specify the moment of inertia about the x-axis,
iyy *mom*	to specify the moment of inertia about the y-axis,
izz *mom*	to specify the moment of inertia about the z-axis,
pdamp *alpha*	for the proportional damping factor (ABAQUS), and/or
cdamp *fraction*	for the fraction of critical damping (ABAQUS).

Remarks

This is distinguished from a node which is created separate from the mesh, assigned a mass, and then later attached to the mesh by a beam or spring. This latter type of point mass is created using the **npm** command, above. The **pm** point mass is replicated along with the present part (see **lrep**, **grep**, and **pslv**). In order to assign a point mass to any node in the mesh such that it does not get replicated or transformed along with the present part, use the **pm** command in the Merge Phase. In order to create a new node and assign it a point mass such that it does not get replicated or transformed along with the present part, then use the **npm** command in the Merge Phase.

spdp assigns a face to be half of a set of spring/damper pairs

spdp *region spring/damper_#* **M** *scale_factor options* ;
or
spdp *region spring/damper_#* **S** *options* ;

where

spring/damper_#	is the user-defined set number
M or *S*	indicates Master or Slave

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

scale_factor is a scaling factor for the set
options can be
dx to constrain spring in the x-direction,
dy to constrain spring in the y-direction,
dz to constrain spring in the z-direction,
rx to constrain spring about the x-axis,
ry to constrain spring about the y-axis,
rz to constrain spring about the z-axis,
orop *flag* orientation option,
where flag can be:
0 for spring/damper acts along the axis
1 for deflection/rotations are measured and force/moments applied along the following vector
2 for deflection/rotations are measured and force/moments applied along the projection of the spring/damper onto the plane with the following normal
prflg *flag* print flag,
where flag can be:
0 for forces are printed in DEFORC file
1 for forces are not printed in DEFORC file
ofsi *offset* initial offset,
xco *x-component* x-component of the orientation vector,
yco *y-component* y-component of the orientation vector, and/or
zco *z-component* z-component of the orientation vector.

Remarks

A face can be either a master or slave side to this set of springs. Then each node on the slave side is paired with a node on the master side to form a spring/damper pair. Use the **spd** command to define the properties of the spring/damper. The degrees of freedom to be coupled with the spring/damper are specified for all of the nodes within the specified region.

spring create/modify a spring

spring *spring_# options ;*
where
spring_# is the number of the spring that you are creating, and
options can be:
sinc *increment* increment the spring number when replicating the part,
v1 *i j k* vertex of the part as the first node,

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

pm1 *pointmass_#* point mass as the first node,
pminc1 *increment* first point mass number when making part replications,
dx1 constrain spring in the x-direction at the first node,
dy1 constrain spring in the y-direction at the first node,
dz1 constrain spring in the z-direction at the first node,
rx1 constrain spring about the x-axis at the first node,
ry1 constrain spring about the y-axis at the first node,
rz1 constrain spring about the z-axis at the first node,
v2 *i j k* vertex of the part as the second node,
pm2 *pointmass_#* point mass as the second node,
pminc2 *increment* increment the second point mass number when making part replications,
dx2 constrain spring in the x-direction at the second node,
dy2 constrain spring in the y-direction at the second node,
dz2 constrain spring in the z-direction at the second node,
rx2 constrain spring about the x-axis at the second node,
ry2 constrain spring about the y-axis at the second node,
rz2 constrain spring about the z-axis at the second node,
sddn *spd_#* material properties,
sminc *increment* increment the SPD number when making part replications,
amp *scale_factor* scale factor for the material properties,
orop *flag* orientation option,
where flag can be:
0 for spring/damper acts along the axis
1 for deflection/rotations are measured and force/moments applied along the following vector
2 for deflection/rotations are measured and force/moments applied along the projection of the spring/damper onto the plane with the following normal
prflg *flag* print flag,
where flag can be:
0 for forces are printed in DEFORC file
1 for forces are not printed in DEFORC file
ofsi *offset* initial offset,
xco *x-component* x-component of the orientation vector,
yco *y-component* y-component of the orientation vector, and/or
zco *z-component* z-component of the orientation vector.

Remarks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This command creates or modifies a spring, with the options, in order to specify the direction of the spring and the material. A node defining the end of the spring can be a vertex of the present part or a point mass (see **npm** and **pm**). The **spring** command is usually invoked twice to generate a single spring, once for each node of the spring. This can be done across several parts or in the Merge Phase. This spring is replicated along with the part (see **lrep**, **grep** and **pslv**). Use the **spd** command to define the properties of the spring.

17. Interfaces and Sliding Surfaces

Objects can be created by which multiple parts will interact with one another. The **bb** command defines a block boundary interface for parts which are not to move with respect to one another. The **trbb** command defines slave transition block boundary interface and is used (in combination with **bb**) anytime that you wish the number of elements to change across an interface. The **bbinfo** command prints information about all of the master block boundary interfaces. Use the following commands to control what block boundary interfaces appear in the picture: **dbb**, **rbb**, **abb**, **dbbs**, **rbbs**, **abbs**, **dabb**, **rabb**. When specifying a sequence of interfaces, type the first and last numbers only with a colon between them.

Use the **sid** command (page ?)to define the properties of a sliding interface. The **si** and **sii** commands are then used to associate regions of the mesh to either the master or slave side of the sliding interface. When using shells for DYNA3D and LSDYNA, be sure to use the **orpt** command to properly orient the faces. Use the **siinfo** command to print a table of information about all of the sliding interfaces. Also, when merging nodes for the first time in the merge phase, additional information will be printed in the text window about the sliding interfaces. Sliding interfaces are not merged.

The **flowint** and **flowinti** commands create named regions for the CFX output file. The **iss** and **issi** command creates saved interface segments for DYNA3D.

bb block boundary interface

bb *region interface [options] transformation* ;

where

interface is the interface number and

transformation is a sequence of transformation operators consisting of a product from left to right of the following:

mx *x_offset*	to translate in the x direction
my *y_offset*	to translate in the y direction
mz *z_offset*	to translate in the z direction
v *x_offset y_offset z_offset*	to translate by a vector

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

scv *xn yn zn offset* to translate a given distance along a vector
dv x_1 y_1 z_1 x_2 y_2 z_2 to translate by a vector given by two points
rx *theta* to rotate about the x axis
ry *theta* to rotate about the y axis
rz *theta* to rotate about the z axis
raxis *angle x0 y0 z0 xn yn zn* axis of rotation
rxy to reflect about the x-y plane
ryz to reflect about the y-z plane
rzx to reflect about the z-x plane
tf *origin x-axis y-axis*
where each of the arguments consist of a coordinate type followed by coordinate information:
rt *x y z* Cartesian coordinates
cy *rho theta z* cylindrical coordinates
sp *rho theta phi* spherical coordinates
pt *c.i* label of a labeled point from a 3D curve
pt *s.i.j* label of a labeled point from a surface
ftf *1st_origin 1st_x-axis 1st_y-axis 2nd_origin 2nd_x-axis 2nd_y-axis*
where each of the arguments consist of a coordinate type followed by coordinate information:
rt *x y z* Cartesian coordinates
cy *rho theta z* cylindrical coordinates
sp *rho theta phi* spherical coordinates
pt *c.i* label of a labeled point from a 3D curve
pt *s.i.j* label of a labeled point from a surface
inv invert the present transformation
csca *scale_factor* to scale all coordinates
xsca *scale_factor* to scale the x coordinate
ysca *scale_factor* to scale the y coordinate
zsca *scale_factor* to scale the z coordinate
normal *delta* offset the slave in the normal direction from the master

option can be any or none of:
map *index* to select the mapping from the slave to master
periodf for Kiva periodic front face
periodp for Kiva periodic derriere face

Remarks

The interface number is used to tie the master and the slaves together. This number refers to a table, so the number must be positive. To be efficient, use a small number. The best method is to start at 1 and increase by 1 for each new interface. Use the automatic parameter %nextbb to get the next available

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

block boundary interface number when defining the master side.

A face, edge, or vertex of a part can be saved to form the geometry of another at later time. This command has several related functions. First it establishes the geometry to be saved. This same command is then used to retrieve the geometry.

To select the face of a part for future reference, select the pertinent region and give it a unique number to identify it. This is referred to as the **master side** of the block interface. Later on, use this same command and select the face, edge, or vertex to be the **slave side**.

It may be useful to create a master block boundary interface, but with no need to save the elements. This can be done by assigning the material number 0 to the part. Elements with material number 0 are not saved.

Conditions and restrictions in the use of this command:

1. The interface region must not have any holes.

2. The first use of the **bb** command defines the master side of the interface. This also means that there can be only one master side and more slave sides of the interface.

3. The coordinates of the corner nodes of the master side (m1,m2,m3,m4) and of the slave side (s1,s2,s3,s4) will be used to determine the best mapping.

There are 8 possible ways that the slave side can be laid onto or mapped to the master side based on 4 rotations (0, 90, 180, and 270 degrees) and 2 symmetries (inversion, no-inversion). The initial coordinates of the slave side determine the best mapping. For all 8 mappings, the distance from the master corners to the corresponding slave corners are calculated (d1,d2,d3,d4). The mapping with the shortest sum of distances is used. If there is no obvious choice, the best selection is made and a warning message is issued.

If, after visually inspecting the mesh in the part phase, it is discovered that the wrong

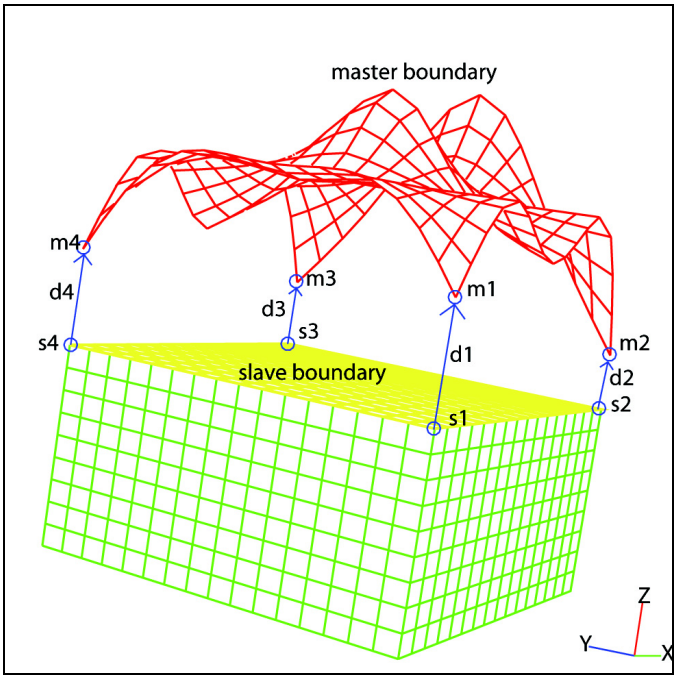


Figure 354 before application of bb

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

choice of mappings was made, simply move the corners of the slave side of the interface to a better initial position. This may get confusing so choose the corner vertices in the computational window. Then choose the coordinates in the physical window and attach. Choose the physical coordinates by displaying the appropriate master block boundary interface in the picture and pick by nodes.

It is possible to force a particular mapping from the slave to the master. This done using the **map** option. Care is needed to choose the correct index for the desired mapping. Below is a chart that shows the 8 different mappings.

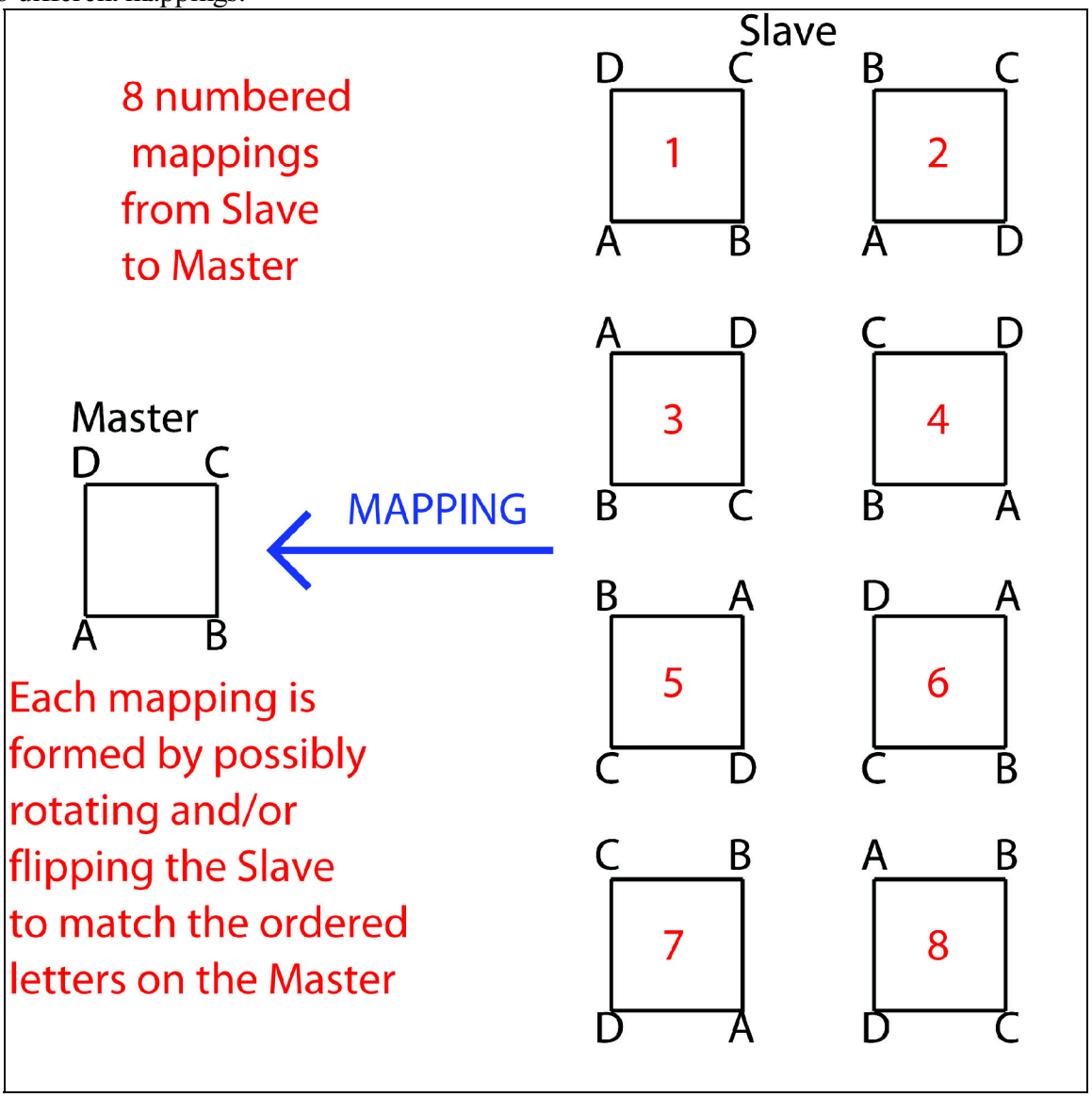


Figure 355 8 ways that the slave side can be mapped to the master side of an interface

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

4. Number of nodes.

When an edge of the slave side is mapped to an edge of the master side, the number of nodes on both edges must be related, either an exact match or the appropriate ratio for the type of transition elements which are to be generated. Suppose the master edge has **m** nodes and the slave has **n** nodes. Then the numbers **m** and **n** must be equal, **m-1** must divide **n-1**, or **n-1** must divide **m-1**. Otherwise there will be an error. If the number of nodes in the master edge is greater than the number of nodes in the slave edge, then nodes in the master side are skipped using a stride. If the number of nodes in the slave edge is greater than the number of nodes in the master edge, then additional nodes are interpolated between the master nodes so that each node on the slave side is placed directly onto the master side of the block boundary interface. This is done independently in both directions along the interface. Therefore it is possible for the master nodes to have a stride in one direction but to be interpolated in another direction.

Further Remarks

True*Grid*® saves the master block boundary interface at the very end of the part generation, regardless of when you issued the command. **True*Grid*®** saves the master side only once for a part and not for any of its duplicates. The slave block boundary interface is performed after the initialization of the part and before any interpolations or projections. These nodes are then frozen. No other command can change the coordinates of the slave nodes in a block boundary interface.

Things are a little more complicated if the slave side of the block boundary interface is in the same part as the master side, but the results are the same. This is known as an intra-part block boundary interface. The special restriction on the intra-part block boundary is that care must be taken to do reasonable things. This is not an iterative process so a complex dependency of the coupling of multiple pairs of faces using this command may not work.

The geometry of the block boundary interface is initially in the local coordinate system of the part. In most cases, no transformation is required. Use the *transformation* option to place the interface in the global coordinate system if it differs from the local coordinate system of the part. If you are creating the master side of the interface, you may wish to transform the interface to the global

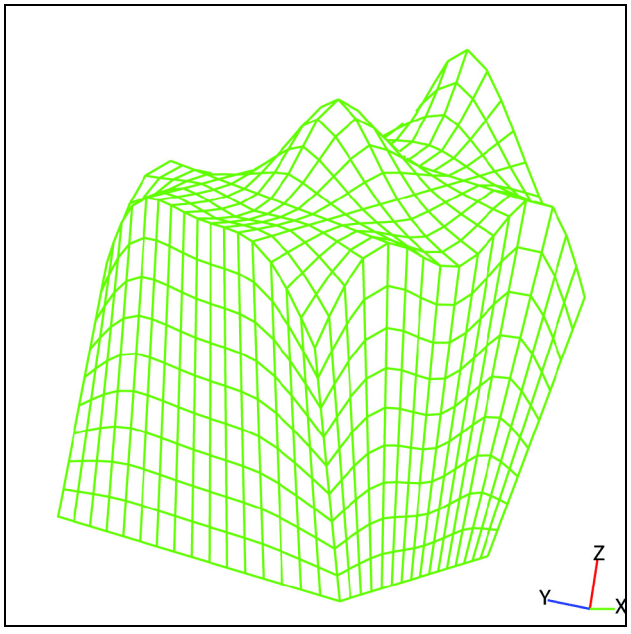


Figure 356 rotated master side of bb

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

system (356). The simplified command file is:

... master part definition...

```
bb 1 1 1 5 5 1 1 rz -20 ry -20;
```
(master block boundary definition- rotated around z and y axes)

... slave part definition...

```
bb 1 1 2 2 2 2 1 ;
```
(slave block boundary definition)

If you are using a transformation on the part to locate it in the global coordinate system, use the same set of operates to transform the interface. When you are defining the slave side of an interface, use the transformation option to indicate how to go from the coordinate system of the master interface part to the coordinate system of the slave interface part. When it is used, a transformation is needed for the master or the slave side but never both. When a transformation is used on the master side, think of it as being saved in a location convenient for the slave side. When a transformation is used on the slave side, think of it as instructions on how to move the master side to the slave side. If the master interface part and the slave interface part are both in the same local coordinate systems, there is no need for a transformation.

Many slave sides can be mapped onto one master interface. This usually means that each slave side **bb** command will include a transformation. One part may use the same interface for several faces of the mesh with different transformations. This is one way to create a section of a periodic mesh (357). The simplified command file:

... master part definition...

```
bb 1 1 1 5 5 1 1 ;
```
(master block boundary definition)

... slave part definition...

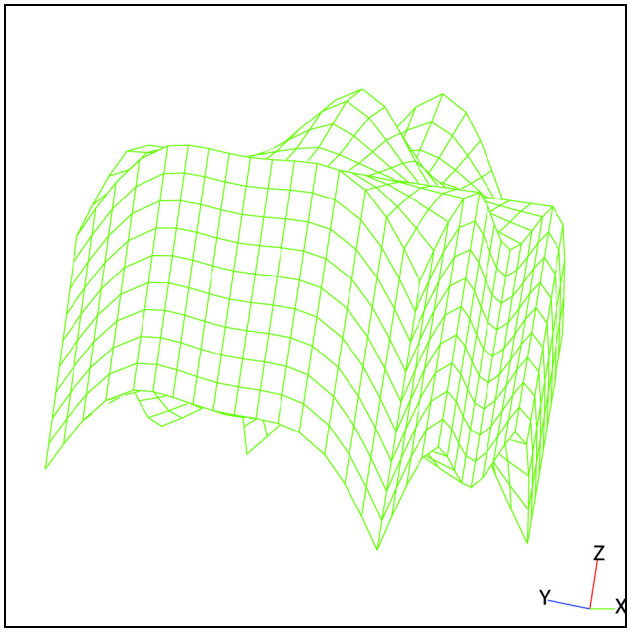


Figure 357 1 master and 2 slaves

```
bb 1 1 2 2 2 2 1 ;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

(slave block boundary 1 definition)

```
bb 1 1 1 2 2 1 1  mz -5;
```

(slave block boundary 2 definition - translated in the z-direction)

The normal operator will offset each node of the slave side in the normal direction from the master side (358). The simplified command file:

... master part definition...

```
bb 1 1 1 5 5 1 1 ;
```

(master block boundary definition)

... slave part definition...

```
bb 1 1 1 2 2 1 1
      normal 1.2 mz 6;   ;
```

(slave block boundary definition - normal operator and translated in the z-direction)

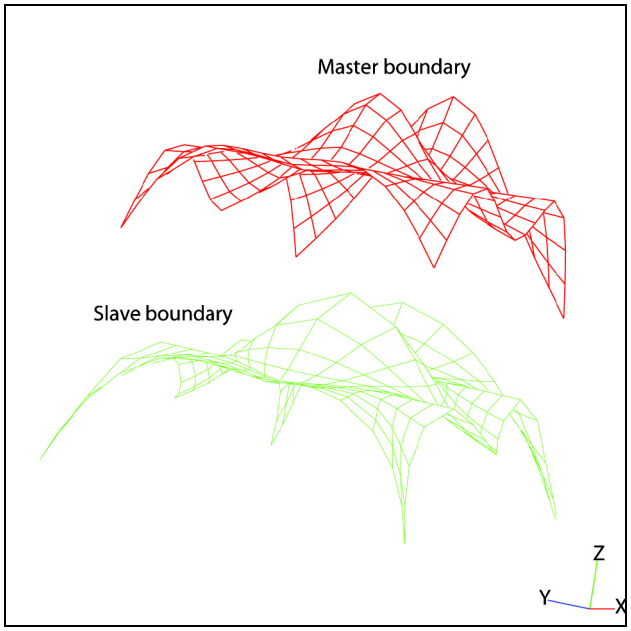


Figure 358 normal operator

A part can be created simply to define a block boundary master interface. The elements of a part will be not be added to the **True*Grid*®** data base (elements will be ignored), if the material number for those elements is set to zero (use **mate**, **mt**, or **mti**).

bbinfo block boundary interface information

bbinfo

Remarks

Only the master side of the interface appears in this table. Additional information is printed when first entering the merge phase and performing nodal merging. Master interfaces defined within a part are not included in the table while in that part generation phase. Only after that part is completed will its master block boundary interfaces appear in the table.

Example

The following commands form 7 parts. The first part is a simple cylinder formed with a single block.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Each of the faces of this part forms master side of another block boundary. Each of the subsequent parts are glued to this center part using the block boundary interface command.

```
sd 1 sp 0 0 0 1
block 1 11; 1 11; 1 11;-1 1 -1 1 -1 1
sfi -1 -2; -1 -2; -1 -2;sd 1
bb 1 1 1 1 2 2 1;
bb 2 1 1 2 2 2 2;
bb 1 1 1 2 1 2 3;
bb 1 2 1 2 2 2 4;
bb 1 1 1 2 2 1 5;
bb 1 1 2 2 2 2 6;
block 1 11;1 11;1 11;-3 -1 -3 3 -3 3
bb 2 1 1 2 2 2 1;
block 1 11;1 11;1 11;1 3 -3 3 -3 3
bb 1 1 1 1 2 2 2;
block 1 11;1 11;1 11;-3 3 -3 -1 -3 3
bb 1 2 1 2 2 2 3;
block 1 11;1 11;1 11;-3 3 1 3 -3 3
bb 1 1 1 2 1 2 4;
block 1 11;1 11;1 11;-3 3 -3 3 -3 -1
bb 1 1 2 2 2 2 5;
block 1 11;1 11;1 11;-3 3 -3 3 1 3
bb 1 1 1 2 2 1 6;
merge
```

The **bbinfo** command then produced this table of master block boundaries.

```
 Master Block Boundary Interface Table
 BB number      1 is     11 by     11 nodes
 BB number      2 is     11 by     11 nodes
 BB number      3 is     11 by     11 nodes
 BB number      4 is     11 by     11 nodes
 BB number      5 is     11 by     11 nodes
 BB number      6 is     11 by     11 nodes
```

dbb display a block boundary in the picture

dbb *interface_number*

where

interface_number is the block boundary interface number

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rbb remove a block boundary from the picture

rbb *interface_number*

where

interface_number is the block boundary interface number

abb add a block boundary to the picture

abb *interface_number*

where

interface_number is the block boundary interface number

dbbs display a set of block boundaries in the picture

dbbs *interface_list* ;

where

interface_list is a list of block boundary interface numbers

rbbs remove a set of block boundaries from the picture

rbbs *interface_list* ;

where

interface_list is a set of block boundary interface numbers

abbs add a set of block boundaries to the picture

abbs *interface_list* ;

where

interface_number is a set of block boundary interface numbers

dabb display all block boundaries

dabbs

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rabb remove all block boundaries from the picture

rabb

bbint block boundary interior mesh lines

bbint *switch*
where
switch can be

on	all interior mesh lines are shown (default)
off	all interior mesh lines are not shown

Remarks

This option works for the wire, hide, and fill modes.

chz cohesive shell elements

chz *region mat*
where
mat material number for the cohesive

Remarks

This is for LS-DYNA output only.

All shells found in the region are included in the cohesion calculation. Every edge shared by two shells will be separated by a zero thick cohesion element and assigned material number *mat*. This applies to transitional regions and to edges with more than two shells.

In the example on the right, there are 9 original shell elements (in green).

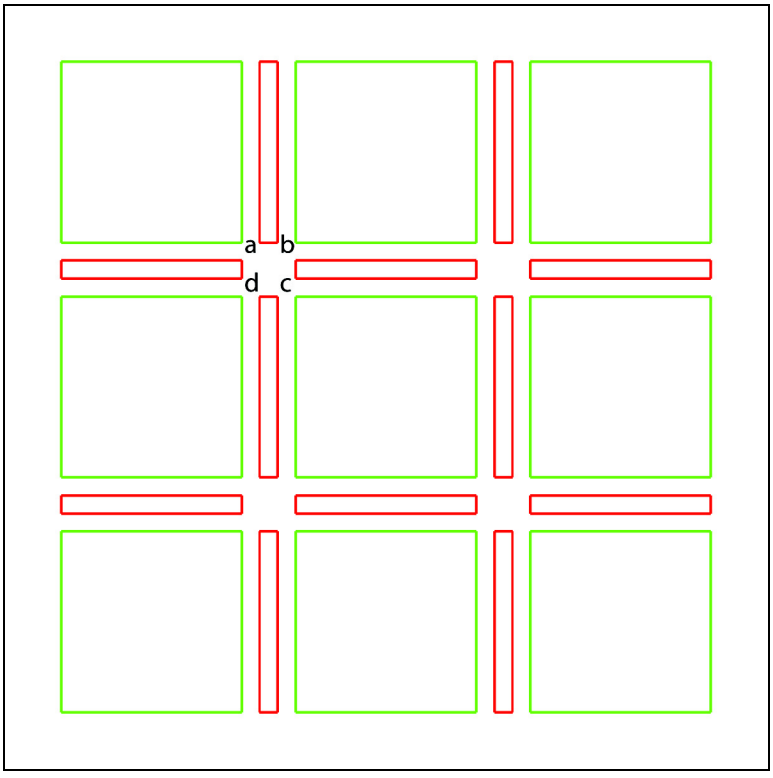


Figure 359 Cohesive shell elements inserted (red)

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The zero width cohesive elements (in red) are shown to have thickness in this diagram. Gaps have also been inserted between elements. The 4 nodes (originally 1 node) labeled a, b, c, and d all have the same coordinates. One original element and two cohesive elements share each of these 4 nodes.

This has not yet been generalized to triangular shells.

If an edge is selected, it will cause the material for the cohesive element to be changed along that edge. If the cohesive elements in a region or an edge have the material specified more than once, the last material number assigned will be used.

chzi cohesive shell elements

chzi *progression mat*

where

mat material number for the cohesive

Remarks

All shells found in the region are included in the cohesion calculation. Every edge shared by two shells will be separated by a zero thick cohesion element and assigned material number *mat*. This applies to transitional regions and to edges with more than two shells.

This has not yet been generalized to triangular shells.

If an edge is selected, it will cause the material for the cohesive element to be changed along that edge. If the cohesive elements in a region or an edge have the material specified more than once, the last material number assigned will be used.

flowint create named regions for the CFX output file

flowint *region interface_type interface_name*

where

interface_type can be one of:

press	pressure face
symmet	symmetry plane
wall	define a wall
cndbdy	define a conducting boundary
inlet	define a generic inlet
outlet	define a generic outlet

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

user2d	specify a user-defined 2D region
solid	specify a non-conducting solid
solcon	specify a conducting solid
porous	specify a porous solid
user3d	specify a user-defined 3D solid
interface_name	character string name (no blanks, up to 30 characters).

Remarks

These regions include both 2D and 3D regions. Any 2D region should be the outer boundary of a part, or of a region specified using the **supblk** command. Otherwise an error will result within CFX. There are no restrictions for 3D regions. If you assign the same name to different regions, or to a region that is broken across blocks, then these regions are assembled into one group of regions for CFX.

flowinti create named regions for the CFX output file

flowinti *progression interface_type interface_nam*e

where

interface_type can be

press	to specify a pressure face,
symmet	to specify a symmetry plane,
wall	to specify a define a wall,
cndbdy	to specify a define a conducting boundary
inlet	to specify a define a generic inlet,
outlet	to specify a define a generic outlet,
user2d	to specify a user-defined 2D region,
solid	to specify a non-conducting solid,
solcon	to specify a conducting solid,
porous	to specify a porous solid, or
user3d	to specify a user-defined 3D solid, and
interface_name	to specify a character string name (no blanks, up to 30 characters).

Remarks

These regions include both 2D and 3D regions. Any 2D region should be the outer boundary of a part, or of a region specified using the **supblk** command. Otherwise an error will result within CFX. There are no restrictions for 3D regions. If you assign the same name to different regions, or to a region that is broken across blocks, then these regions are assembled into one group of regions for CFX.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

iss save interface segments

iss *region*

issi save interface segments

issi *progression*

si assign sliding interface to region

si *region sliding_# type options*

where

sliding_# reference number for the interface

type **m** for master and **s** for slave

options this depends on the *type*.

If the *type* is **s**, then the *options* can be

[*normal_failure_stress_or_force shear_failure_stress_or_force*
[*exponent_for_normal_force exponent_for_shear_force*]]

fsf *Coulomb_friction_scale viscous_friction_scale*

where the first pair of parameters must be specified in order to specify the second pair of parameters.

If the *type* is **m**, then *options* can be

fsf *Coulomb_friction_scale viscous_friction_scale*

Remarks

The sliding interface number is used to identify the interface. There are three components to a typical sliding interface: master nodes/faces, slave nodes/faces, and the properties. The identification number ties all three components together. This number refers to a table, so it must be positive. To be efficient, use a small number. The best method is to start at 1 and increase by 1 for each new interface.

The **fsf** option is for LS-DYNA. The other options are for both LLNL-DYNA3D and LS-DYNA.

This command, and its relative **sii**, specify that faces in the mesh are part of a sliding interface. You can use these commands to assign a shell or brick face to a sliding interface definition. In order to define the properties of the sliding interface, first use the command **sid**. **Sid** defines the properties of the sliding interface that you refer to in **si** and **sii**.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Surfaces from 3D solid brick elements have an obvious orientation pointing outward. However, this is not the case with sliding interfaces on 2D shell surfaces. You must provide information about how to orient them. That is the purpose of the **orpt** command.

During the node merging process using, using **stp** for example, **True*Grid*®** will not merge nodes on opposite sides of a sliding interface.

Use the merge phase command **co** with the **si** option to view the numbered sliding interfaces and their orientation.

Example

An example is provided with the following command, **sii**. This command is the same as **si** except that multiple regions may be specified using a reduced index progression.

sii assign sliding interfaces

sii *progression sliding_# type options*

where

sliding_# sliding interface reference number

type **m** for master and **s** for slave

options this depends on the *type*.

If the *type* is **s**, then *options* can be

[normal_failure_stress_or_force shear_failure_stress_or_force
[exponent_for_normal_force exponent_for_shear_force]]

fsf Coulomb_friction_scale viscous_friction_scale

where the first pair of parameters must be specified in order to specify the second pair of parameters.

If the *type* is **m**, then *options* can be

fsf Coulomb_friction_scale viscous_friction_scale

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

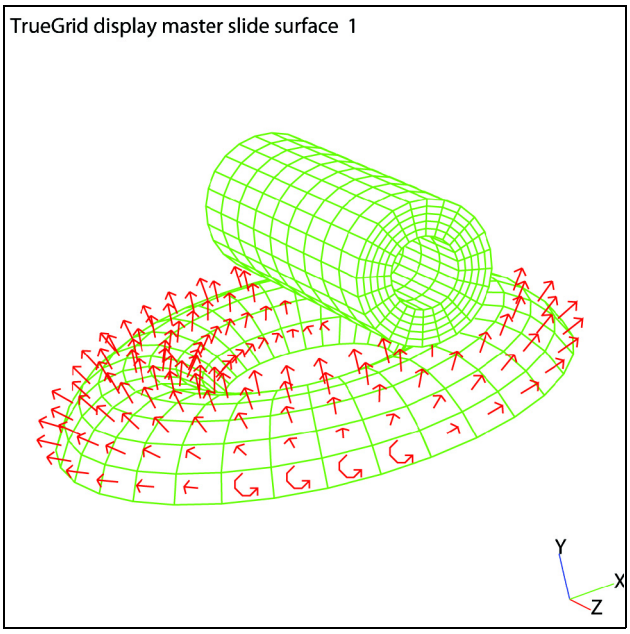


Figure 360 master side of interface

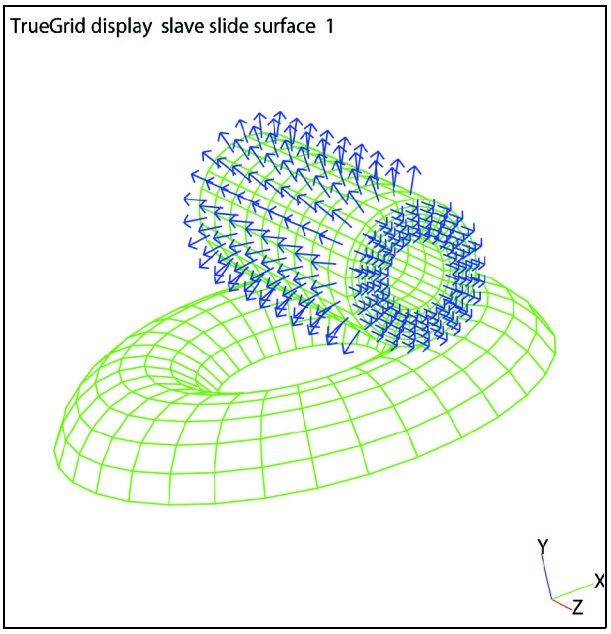


Figure 361 slave side of interface

Figure 360 and **Figure 361** were created by the use of the following command file. Some normals are displayed as circular arcs with arrows. This is caused by the normals pointing almost orthogonally from the screen. There is an angle parameter in the **condition** command setting the range of such behavior. You can modify it, or totally disable it.

```
c  Definition of the geometry

c Sliding Interface -> master side
c Part definition -> shells.
block 1 3 5 7 9;-1;1 3 5 7 9; 0 2 4 6 8; 9 ; 0 2 4 6 8;

c  Manipulations of the mesh

c Definition of orientation point in Cartesian coord x,y, and z
orpt - 9 0 9

c Definition of the type of the sliding interface
sid 1 sv ;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
c Assignment of region (;-1;;) and type(1 m)of slid. interf.
sii ;-1;; 1 m

c Definition of 3 global transformations around y-axis
gct 3 ry 90; ry 180; ry 270 ;  c for 90,180 and 270 degrees.

c Global replication 3 times by rotation for
grep 0 1 2 3;  90,180 and 270 degrees

c Cylinder part -> tube made from hexahedrons.
cylinder 1 6; 1 3 5 7 9 11 13 15 17 19 21 23 25; 1 10;
     2 4;0 30 60 90 120 150 180 210 240 270 300 330 360;0 20;

c Definition of the orientation point in the default coordinate
c system of the part (in Cylindrical coordinates r,eta,z).
orpt - 0 20 5

c Assignment of region (-2;;) and type(1 s) of slid. interf.
sii -2;;; 1 s

c Assignment of region (;;-1;) and type(1 s) of slid. interf.
sii ;;-1; 1 s

c Assignment of region (;;-1;) and type(1 s) of slid. interf.
sii ;;-2; 1 s

lct 1 my 20 ;  c Definition of the local transformation
lrep 1;        c Transformation 1 is applied.

merge

labels size 3       c Scale the size of arrows.
rx 20 ry 20 rz 20   c Rotate mesh in window.
center              c Center picture in window.
set tv disp         c Set hide display option.

co si 1 m;     c Display of master side of sliding interface 1

disp

co si 1 s;     c Display of slave side of sliding interface 1

disp
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

sinfo c sliding interface information

trbb slave transition block boundary interface

trbb *region interface transform ;*

where

interface is the interface number and

transform is a product from left to right of the following:

mx *x_offset* to translate in the x direction

my *y_offset* to translate in the y direction

mz *z_offset* to translate in the z direction

v *x_offset y_offset z_offset* to translate by a vector

scv *xn yn zn offset* to translate a given distance along a vector

dv x_1 y_1 z_1 x_2 y_2 z_2 to translate by a vector given by two points

rx *theta* to rotate about the x axis

ry *theta* to rotate about the y axis

rz *theta* to rotate about the z axis

raxis *angle x0 y0 z0 xn yn zn* axis of rotation

rxy to reflect about the x-y plane

ryz to reflect about the y-z plane

rzx to reflect about the z-x plane

tf *origin x-axis y-axis*

where each of the arguments consist of a coordinate type followed by coordinate information:

rt *x y z* Cartesian coordinates

cy *rho theta z* cylindrical coordinates

sp *rho theta phi* spherical coordinates

pt *c.i* label of a labeled point from a 3D curve

pt *s.i.j* label of a labeled point from a surface

ftf *1st_origin 1st_x-axis 1st_y-axis 2nd_origin 2nd_x-axis 2nd_y-axis*

where each of the arguments consist of a coordinate type followed by coordinate information:

rt *x y z* Cartesian coordinates

cy *rho theta z* cylindrical coordinates

sp *rho theta phi* spherical coordinates

pt *c.i* label of a labeled point from a 3D curve

pt *s.i.j* label of a labeled point from a surface

inv invert the present transformation

csca *scale_factor* to scale all coordinates

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

xsca *scale_factor* to scale the x coordinate
ysca *scale_factor* to scale the y coordinate
zsca *scale_factor* to scale the z coordinate
normal *delta* offset the slave in the normal direction from the master
option can be any or none of:
map *index* to select the mapping from the slave to master
periodf for Kiva periodic front face
periodp for Kiva periodic derriere face

Conditions and restrictions on the use of this command:

1. The master side comes from a part that is generated first.

2. The interface region must not have any holes.

3. The first use of the **bb** command defines the master side of the interface.

It also means that there can be only one master side and one or more slave sides of the interface.

4. The coordinates of the corner nodes of the master side (m1,m2,m3,m4) and of the slave side (s1,s2,s3,s4) will be used to determine the best mapping.

There are 8 possible relative positions of master and slave based on 4 rotations and 2 symmetries. Initial coordinates of the slave determine the best mapping. For all 8 positions, the distance from the master corners to the slave corners are calculated (d1,d2,d3,d4). The position with the smallest sum of distances between corners is used for the mapping. If there is no obvious choice, the best selection is made and a **warning message** is issued.

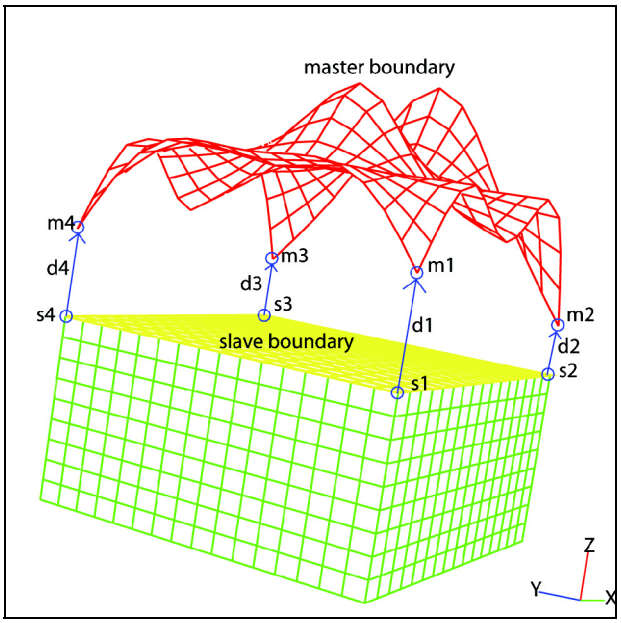


Figure 362 before application of bb

It is possible to force a particular mapping from the slave to the master. This done using the **map** option. Care is needed to choose the correct index for the desired mapping. In the discussion for the **bb** command is a chart that shows the 8 different mappings.

6. The number of elements on the master and

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

slave sides of the boundary must be related.

In one direction of the interface, the number of elements must match (be the same). In the other direction, one side must have **2** or **3** times the number of elements as the other side. Where the ratio is **2**, both sides must have an even number of elements in their respective directions (**4:2**). In other words, acceptable ratios are either 1:3 or 2:4.

Remarks

The interface number is used to tie the master and the slaves together. This number refers to a table, so the number must be positive. To be efficient, use a small number. The best method is to start at 1 and increase by 1 for each new interface.

This command forms a transition region to make a face of one "slave" part fit the face of another "master" part. The master side of the transition block boundary is formed using the **bb** command. The number of elements on the master and slave side must be related.

If the part is formed of hexahedral elements, then the transition will also be of all hexahedral elements. In one direction of the interface, the number of elements must match. In the other direction, one side must have **2** or **3** times the number of elements as the other side. Where the ratio is **2**, both sides must have an even number of elements in their respective directions (**4:2**).

Example

```
block
1 3 5 7 9;
 1 3 5;
  1 3 5 7 9;
1 3 5 7 9;
 1 3 5;
  1 3 5 7 9;
c dense part - Part 1

bb 1 1 1 5 1 5 1 ;
c Master side
```

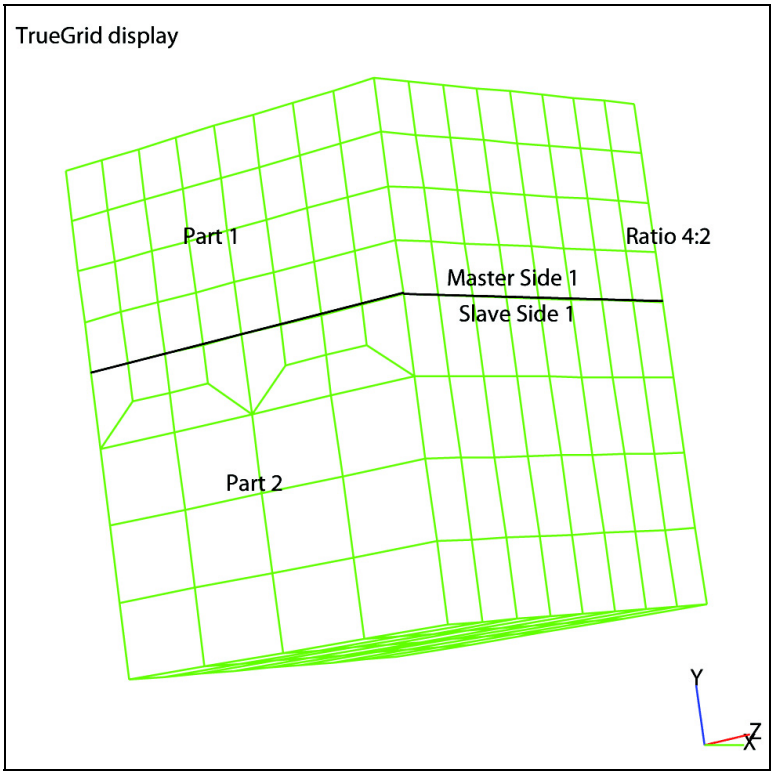


Figure 363 transition in mesh density by **trbb**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
c definition

block
1 3 5 7 9;
 1 3 5;
  1 3 5;
1 3 5 7 9;
 -5 -2 1;
   1 5 9;
c sparse part - Part 2

trbb
1 3 1 5 3 3 1 ;
c Slave side 1 definition

merge
```

Example

You can gradually make a transition in mesh density in two directions (**Figure 364**).

```
block 1 3 5 7 9; 1 3 5; 1 13;  1 3 5 7 9; 1 3 5; 1 9;
     c dense part - Part 1

bb 1 1 1 5 1 2 1 ;       c Master side 1 definition

block 1 3 5 7 9;1 3 5; 1 3 5;1 3 5 7 9;-5 -2 1;1 5 9;
     c sparse part 1 - Part 2

trbb 1 3 1 5 3 3 1 ;     c Slave side 1 definition

bb 1 1 1 5 1 3 2 ;       c Master side 2 definition

block 1 3 5;1 3 5; 1 3 5;1 5 9;-10 -7.5 -5;1 5 9;
     c sparse part 2 - Part 3

trbb 1 3 1 3 3 3 2 ;          c Slave side 2 definition
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

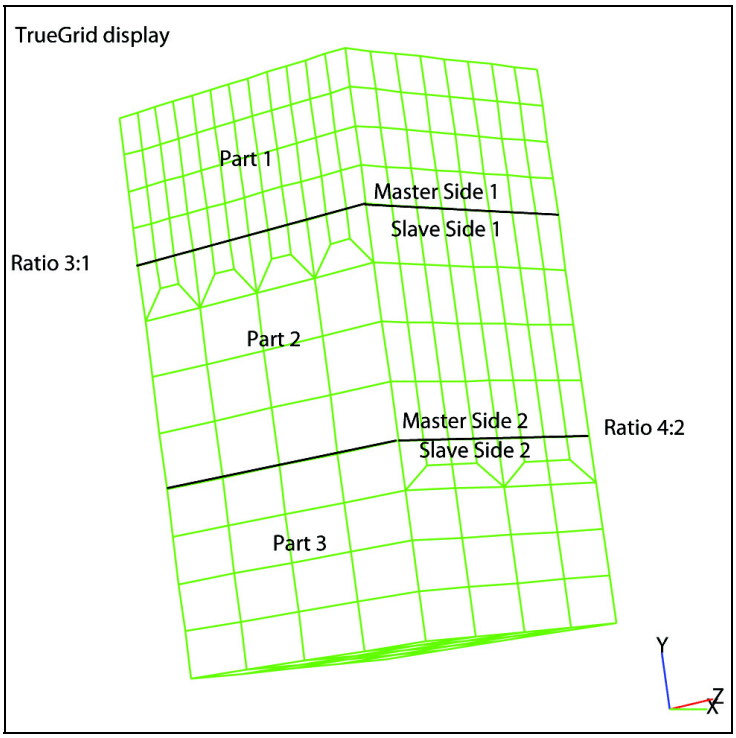


Figure 364 transition in mesh density by **trbb**

Example

If the part is made of quadrilateral shell elements, the transition elements will all be quadrilateral elements. One side must have **2** or **3** times the number of elements as the other side. Where the ratio is **2**, both sides must have an even number of elements in their respective directions (**4:2**) (365).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
block
 1 3 5 7 9; 1 3 5; -1;
   1 3 5 7 9; 1 3 5; 1;

bb 1 1 1 5 1 1 1 ;
     c Master side 1
     c definition
     c endpart
block
 1 3 5;1 3 5; -1;
     1 5 9;-5 -2 1;1;
     c sparse part - Part 2
trbb 1 3 1 3 3 1 1 ;
     c Slave side 1
     c definition
     c endpart
merge
```

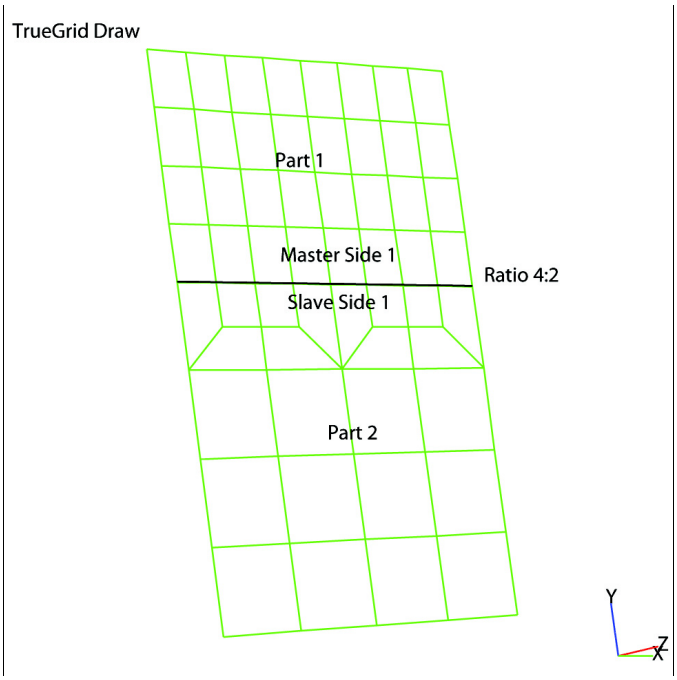


Figure 365 transition in mesh density by trbb

Example

The transition in mesh density of this example is dependent upon the order of the parts. Part 1 is inside the thickened square and Part 2 is outside the thickened square. The mesh shown in 366 results from defining Part 1 first and Part 2 second. The **trbb** command is used on each of the four shared edges. The elements of the second part are modified to transition between the different mesh densities. It would be an error to switch the order of parts, because transitions in 2 directions are not allowed on the same block. The command file follows:

```
block
1 9;1 9;-1;5 10;5 10;0;
```

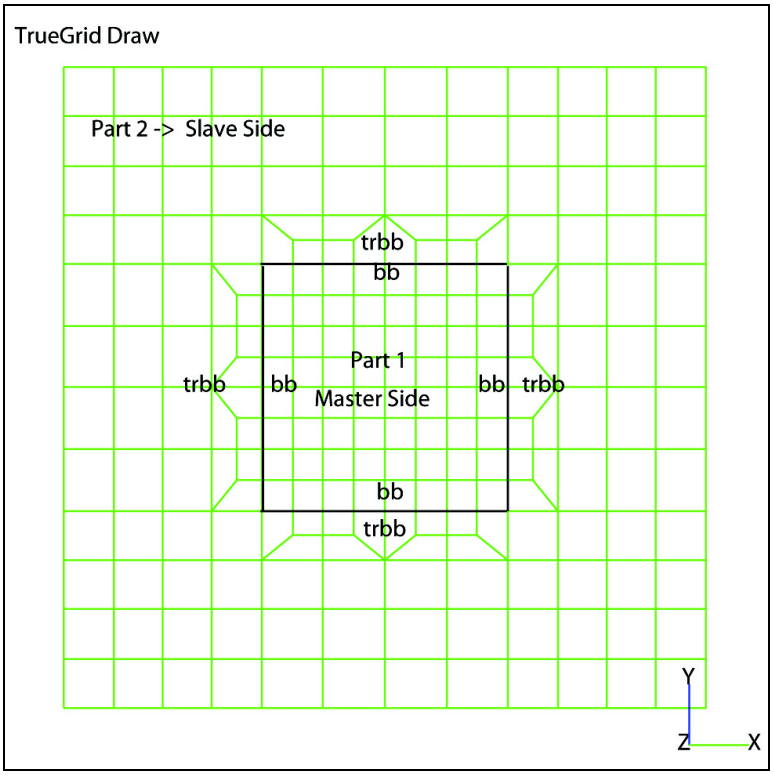


Figure 366 transition in mesh density by trbb

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
 c Part 1 definition

bb 1 1 1 1 2 1 1 ;
bb 1 2 1 2 2 1 2 ;
bb 2 1 1 2 2 1 3 ;
bb 1 1 1 2 1 1 4 ;
  c block boundary
  c definitions 1 2 3 4
  c for Part 1

block
 1 3 5 9 11 13;
 1 3 5 9 11 13;-1;
 1 3 5 10 12 14;
 1 3 5 10 12 14;0;
  c Part 2 definition

dei 3 4;3 4;;
  c region deletion

trbb 3 3 1 3 4 1 1 ;
trbb 3 4 1 4 4 1 2 ;
trbb 4 3 1 4 4 1 3 ;
trbb 3 3 1 4 3 1 4 ;
  c transition block boundary definitions  1 2 3 4 for Part 2
merge
```

Remarks

When the **trbb** command is used in a part different to the part, where the master side is defined, the part with the **trbb** command must be created after the part with the **bb** command. In other words, the master side of the interface must be defined before the slave side of the interface can be attached to it. This holds true as well when the master side and the slave side are found within the same part. The **bb** command that defines the master side must come before the **trbb** command that defines the slave side.

The **trbb** block boundary interface is performed after the initialization of the part and before any interpolations or projections. These nodes are then frozen. No other command can change the coordinates of the nodes in a **trbb** block boundary interface. After the part is completed and either a new part is initialized or the **endpart** command is issued, then the elements at the interface are rearranged to form the interface so that both sides of the interface match. You will only be able to see the transition interface in the Merge phase.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The geometry of the block boundary interface is initially in the local coordinate system of the part. In most cases, no transformation is required. Use the *transformation* option to place the interface in the global coordinate system if it differs from the local coordinate system of the part. When you are defining the slave side of an interface, use the transformation option to indicate how to go from the coordinate system of the master interface part to the coordinate system of the slave interface part. When it is used, a transformation is needed for the master or the slave side but not both. When a transformation is used on the slave side, think of it as instructions on how to move the master side to the slave side. If the master interface part and the slave interface part are both in the same local coordinate systems, there is no need for a transformation.

Many slave sides can be mapped onto one master interface. This usually means that each slave side **trbb** command will include a transformation. One part may use the same interface for several faces of the mesh with different transformations. This is one way to create a section of a periodic mesh.

The normal operator is a special transformation which is valid only in the slave side on a block boundary interface. It will offset each node of the slave side in the normal direction from the master side.

shtoso shell to solid interface by region

shtoso *region id info*

where *id* is a positive integer

where *info* must be one of

edge	for shells only
i *b a*	for solids only
j *b a*	for solids only
k *b a*	for solids only

where

b	the number of nodes before the solid element edge
a	the number of nodes after the solid element edge

Remarks

This command defines a shell to solid interface for LS-DYNA. A vertex or an edge of a shell is selected and assigned an identification number. In another instance of this command with the ame identification number, an edge of a solid and its neighboring nodes are selected to form fibers. The nodes forming a fiber are constrained to the appropriate node selected along the shell edge with a matching identification number. This command can be issued several times to select all of the nodes forming a set of fibers. Each valid shell edge node is paired to the fiber which is closest.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Care should be taken so that a fiber is not used more than once. LS-DYNA expects that the nodes along a fiber are co-linear. You must take the correct actions to be sure this is the case in TrueGrid. TrueGrid will issue a warning if the nodes of a fiber are not colinear or if the shell edge node does not fall on the fiber.

Nodes will not be merged across this interface.

Examples

```
lsdyna keyword
sd 1 plan -1.9134172 4.6193977 2.5 1 0 0
sd 2 plan 1.9134172 4.6193977 2.5 1 0 0
sd 3 plan 0 0 0 0 1 0
cylinder 1 3;1 13 21 33;1 6 11;
         5 6 0 67.5 112.5 180 0 2.5 5
bb 1 2 2 1 3 2 1;
shtoso 1 2 2 1 3 2 1 k 1 3
mate 1
endpart
block 1 9;1 11;-1;-2 2 0 5 2.5
bb 1 2 1 2 2 1 1;
sfi -1; 1 2; -1; sd 1
sfi -2; 1 2; -1; sd 2
sfi 1 2; -1; -1; sd 3
mt 1 1 1 2 2 1 2
shtoso 1 2 1 2 2 1 1 edge
endpart
merge
write
```

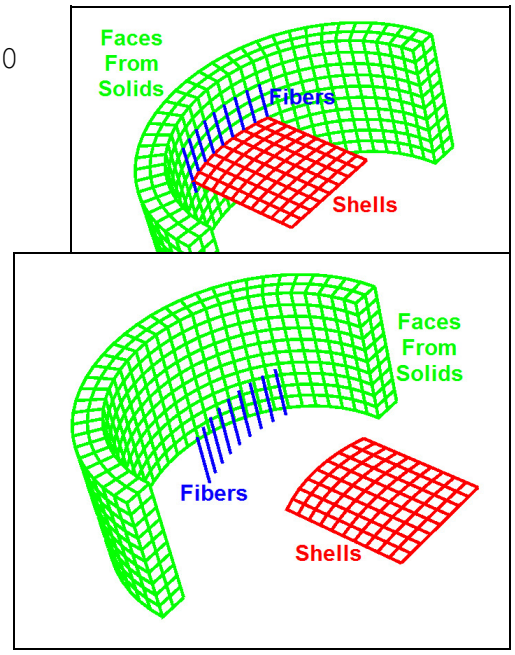


Figure 368 Exploded view

shtosoi shell to solid interface by progression

shtosoi *progression id info*

where *id* is a positive integer

where *info* must be one of

edge	for shells only
i *b a*	for solids only
j *b a*	for solids only
k *b a*	for solids only

where

b	the number of nodes before the solid element edge

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

a the number of nodes after the solid element edge

Remarks

See **shtoso**.

18. Automatic Rivet Hole generation

Rivet holes can be inserted automatically. The cylinder that forms the hole must be (nearly) orthogonal to the face of the block mesh. The block mesh must be (nearly) orthogonal. This command works for both bricks and shells, linear and quadratic.

This command is not needed if the ideal topology for the hole has been built into the design of the block part. But when the mesh density of the block part does not match the mesh density of the desired hole, if you want an easy way to form a symmetric plug around the hole, if you have many holes to add, or if you need to add holes after the model has been completed, then the **hole** command will be ideal. This is an automatic hole capability in that a region around the plug is re-meshed to form a transitional region between the plug and the original block mesh. If there are several holes in proximity, then the region around the plugs will form a single transitional region between the plugs and the surrounding hex mesh.

hole **insert a cylindrical hole**

hole *region x0 y0 z0 xn yn zn radius options* ;
where the *region* must be a face of the part.
where (*x0,y0,z0*) is a point on the centerline or axis of the cylindrical hole
where (*xn,yn,zn*) is the axis direction vector
where *radius* is the (outer) radius of the cylindrical hole
where *option* can be any or all of the following:

inr *radius*	for the inner radius of an annulus
fn *xd yd zd*	for the orientation of the first node in the outer cylinder
net *n*	for the number of elements in the thickness of the annulus
ang *theta*	for the angle of the conic countersink

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

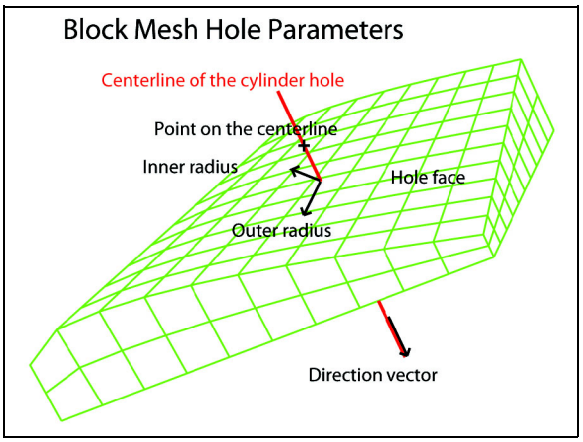


Figure 369 Block before hole inserted

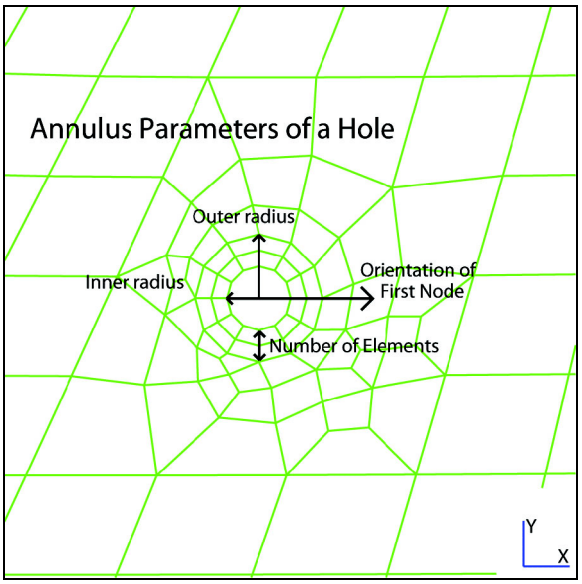


Figure 370 Block after hole inserted

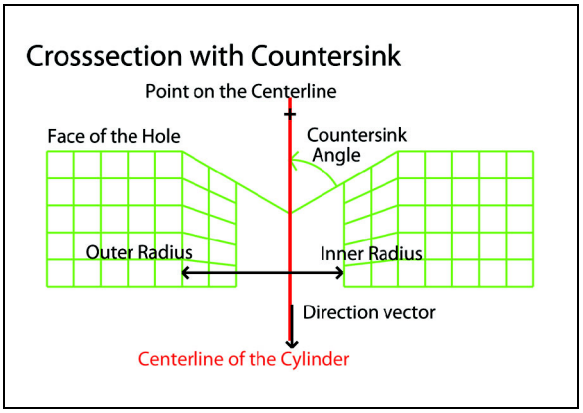


Figure 371 Countersink Diagram

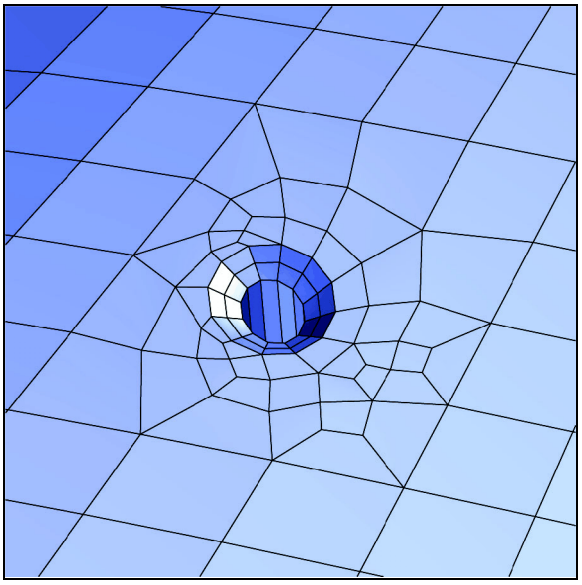


Figure 372 Hole with countersink

Remarks

The hole command creates a cylindrical hole in a block part. A ring of 12 hex elements are formed around the hole to produce a symmetric mesh around the hole. The two faces of the block part, that which is identified by the region and the opposing face of the block must intersect with the cylinders identified in the hole command. Both faces must be projected to a surface. The mesh around the hole

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

and the hole are not visible until after entering the merge phase. This is because the mesh around the hole is not formed until the part is ended, since many commands can effect the shape of the block part before the mesh around the hole is formed.

The process used to form the transition between the block mesh and the hole annulus starts with an automatically formed all quad mesh on the hole face. These quad faces are then extruded in the direction of the cylinder axis to form hex elements filling the gap. Because this is an extrusion process, there are some obvious rules to follow. Two holes must be far enough apart so that a reasonable mesh can be formed between them. Holes can only be applied in one direction. In other words the holes cannot cross. One hole cannot be inside another. The hole must be contained within the boundaries of the part.

The quality of the mesh that transitions from the block mesh to the hole can be low. This is unavoidable when the mesh density between the existing block mesh and the boundary of the hole are very different. To improve the quality, try changing the mesh density of the block mesh. Also, try changing the orientation of the first node. It is also possible to convert some of the hex elements to prism (wedge) elements. Two parameters control the substitution of wedge solids for hex solids in the region between the cylinder hole and the original block structured mesh.:

> **arquah** - ratio for the largest aspect ratio for a quad face in the region between the outer cylinder and the block mesh. If this parameter is set to a number less than 1, then this parameter will not be used to determine the conversion to wedge (prism) elements.
>
> **esquah** - length for the smallest edge length for a quad face in the region between the outer cylinder and the block mesh. If this parameter is set to zero, then this parameter will not be used to determine the conversion to wedge (prism) elements.

When **arquah** is greater than 1 and when **esquah** is positive, than any quad that has an aspect ratio greater than **arquah** and an edge length less than equal to **esquah** will be converted to a triangle face and the resulting extruded solid elements will become prism (wedge) elements.

The **rfholes** command can be used to to enlarge the region that transitions between the block mesh and the hole annulus.

There are some limitations on the shape of the hex mesh in the area of the hole. In particular, the mesh lines of the block part must run nearly parallel to the axis of the cylindrical hole. This requirement will be relaxed in future versions.

There are some limitations on the surfaces being used for projection of the face identified in the hole command. The surfaces that can be used here are:

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

1. all IGES surfaces
2. parameterized surface (function)
3. sphere (sp)
4. ellipsoid (er)
5. tabular (mesh)
6. ruled2d (rule2d) and ruled3d (rule3d)
7. torus (ts, toru)
8. swept (swept)
9. polygon (faceset)
10. pipe (pipe)
11. blended (blend3, blend4)
12. splines (csps, bsps, nrbs, hermite)
13. interpolated (intp)
14. rotated 2D (cr,crx,cry,crz) and 3D (r3dc) curves
15. composites (sds) from any of the above

Basically, unbounded surfaces cannot be used. Also, any surfaces that have edges that are degenerate or that meet with another edge of the same surface cannot have a hole that crosses or contains one or more of these edges. For example, a sphere, cylinder or torus has edges that meet (i.e. they are periodic). Do not confuse this with a composite surface where two or more surfaces have common edges. This hole feature works well where edges from different surfaces meet.

Examples

The following is an example when many close holes are formed in a block with a coarse mesh.

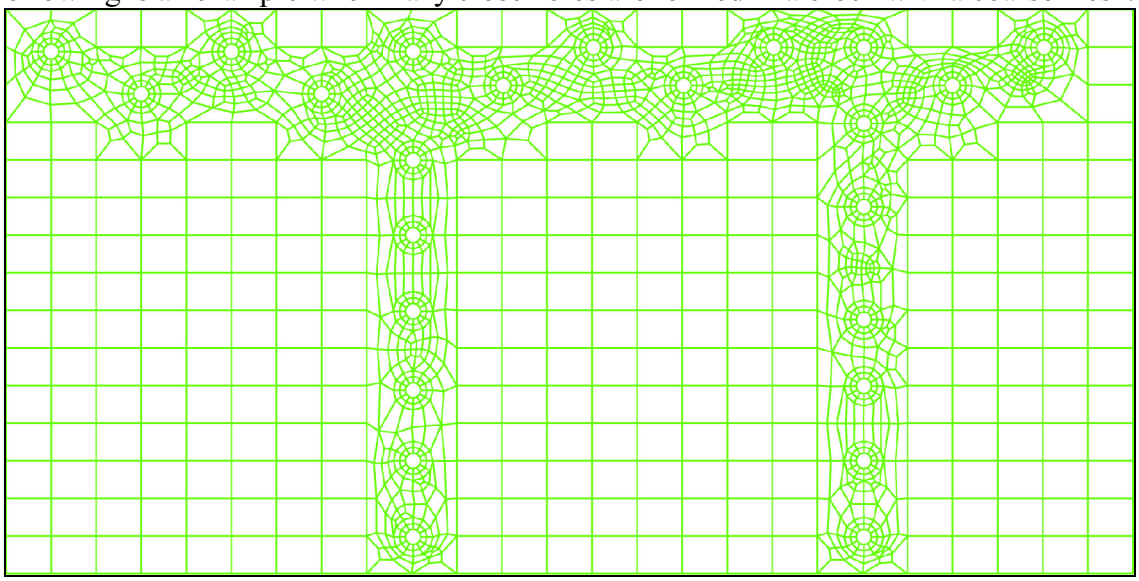


Figure 373 Space between multiple holes and block mesh sewn together

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

In this next example, 39 surfaces from an IGES file are composed. Then a shell mesh is projected to this composite surface an a hole is automatically inserted, using the **hole** command.

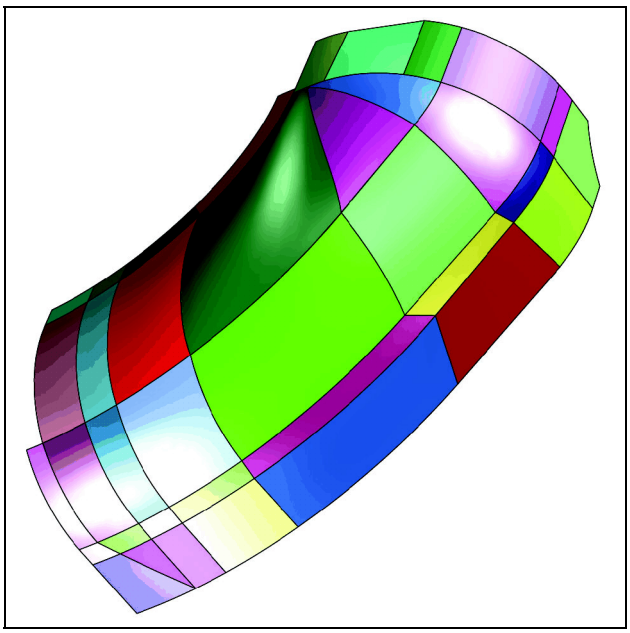


Figure 374 Composite surface from 39 surfaces

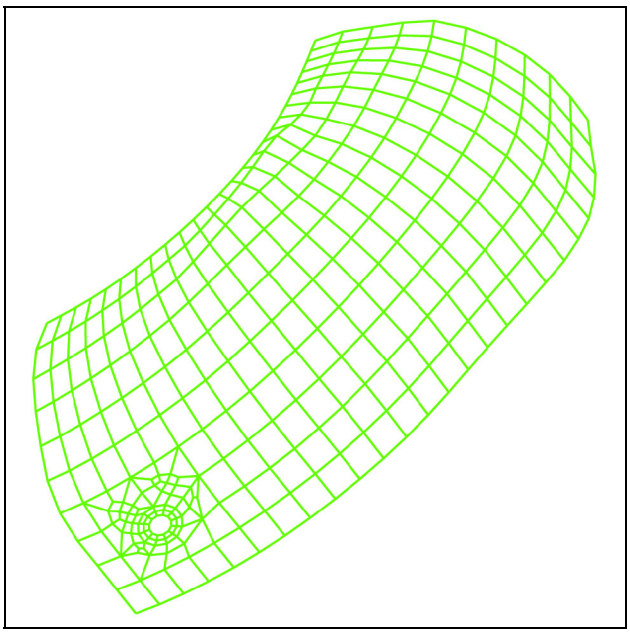


Figure 375A single hole inserted into a shell mesh

rfholes **relative factor for holes**

rfholes *factor*

where *factor* is a number greater than 1

Remarks

The default is 1.95. This factor determines the size of the region in the block mesh that is carved out for the opening to be filled by the **hole** command. This factor is multiplied by the outer radius of the hole and the region carved out of the block mesh must accommodate the cylinder with this radius. By changing this number, the resulting automatic mesh that fills in the region between the annulus of the hole and the boundary formed by the carved out region in the block mesh will change. In most cases, if there is more room in the transition (larger factor) region (the automatic mesh), the higher the quality of the mesh. This is not an absolute and if the quality is not acceptable, then run some experiments with various factors. For higher quality, it may be necessary to increase (or decrease) the mesh density of the block mesh.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

In this example on the right, the relative factor is set to 3. This means that a cylinder with a radius 3 times the outer radius of the hole was used to determine the block carved out of the block mesh before it was filled with a transition mesh between the block mesh and the annulus of the hole.

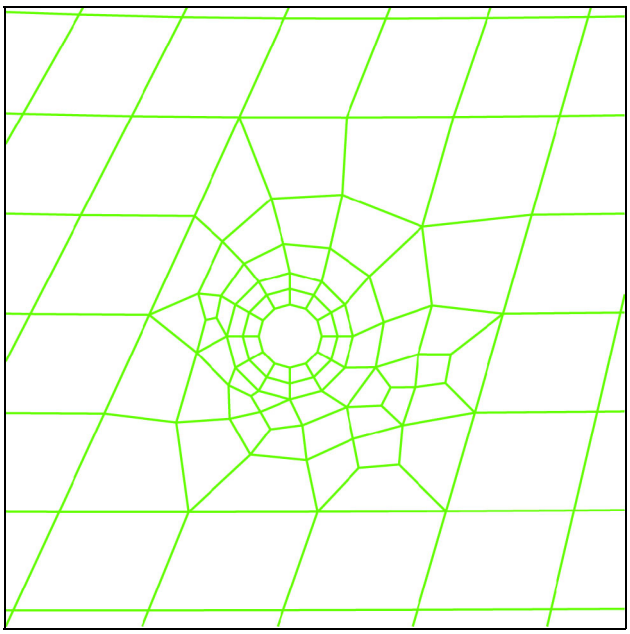


Figure 377 rfholes set to 1.95 (default)

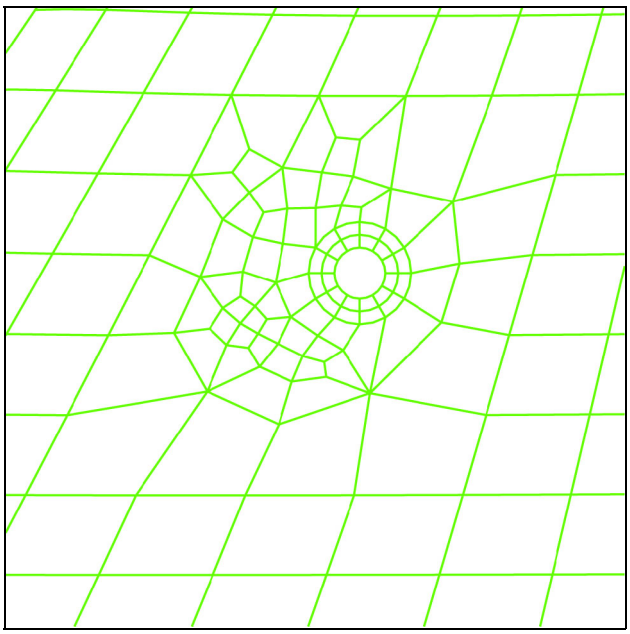


Figure 376 rfholes set to 3

arquah **aspect ration that triggers triangles around holes**

arquah *aspect_ratio*
where *aspect_ratio* is the maximum aspect ration for a quad face

Remarks

The default is infinite. Set **arquah** to zero to return it to the default.

This parameter controls the generation of triangles on the hole face. Triangles are inserted in the transition between the block mesh and the hole annulus after it has been filled with quads. Any quads with and aspect ration greater that **arquah** will be replaced by triangles.

A quad is converted to a triangle by collapsing the smallest edge of the quad. If this edge is along the boundary (i.e. the interface with the block mesh or the interface with the hole annulus), then the quad

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

will not be converted to a triangle.

Example

Compare the left (no triangles) and the right (4 triangles) with reduced aspect ratio.

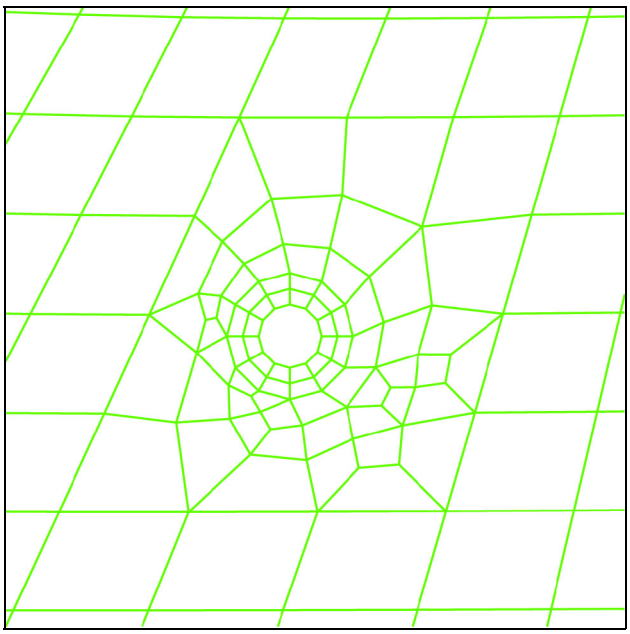


Figure 378 arquah set to infinity (default)

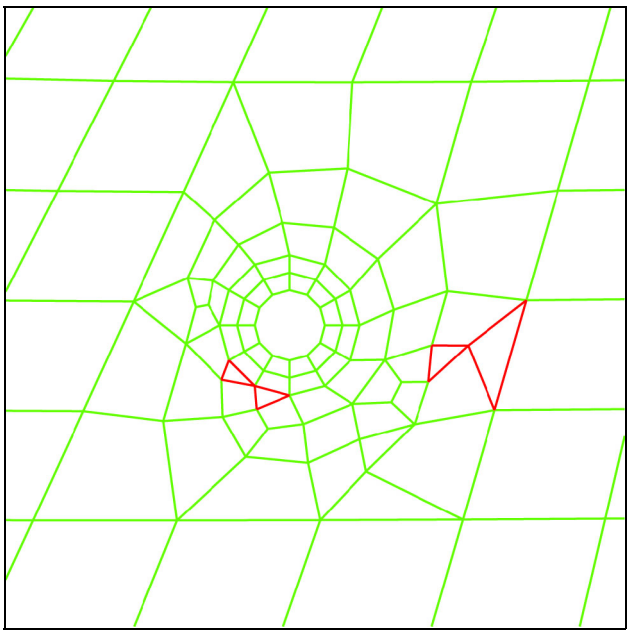


Figure 379 arquah set to 3

esquah **edge size that triggers triangles around holes**

esquah *size*

where *size* is the minimum edge size allowed for a quad.

Remarks

The default is zero.

When the **hole** command is used, after the quads are formed to fill the region between the block mesh and the hole annulus, the quads are inspected. If any quad has an edge less than or equal to the specified minimum, it is marked to be replaced by triangles.

A quad is converted to a triangle by collapsing the smallest edge of the quad. If this edge is along the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

boundary (i.e. the interface with the block mesh or the interface with the hole annulus), then the quad will not be converted to a triangle.

Example

The only difference between the two meshes below is the use of the **esquah** command.

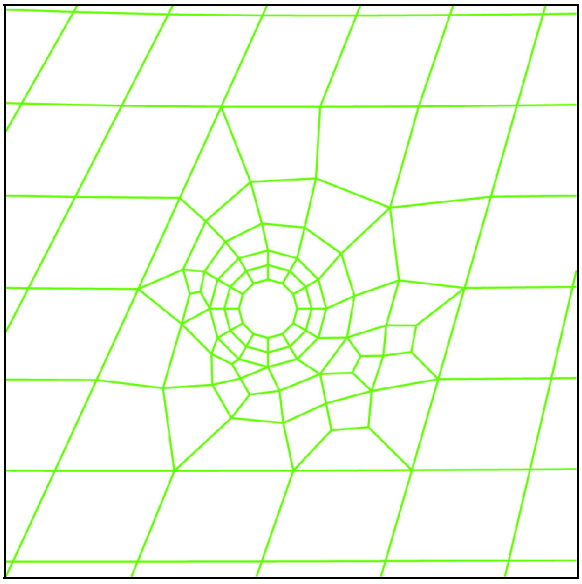


Figure 381 esquah set to zero (default)

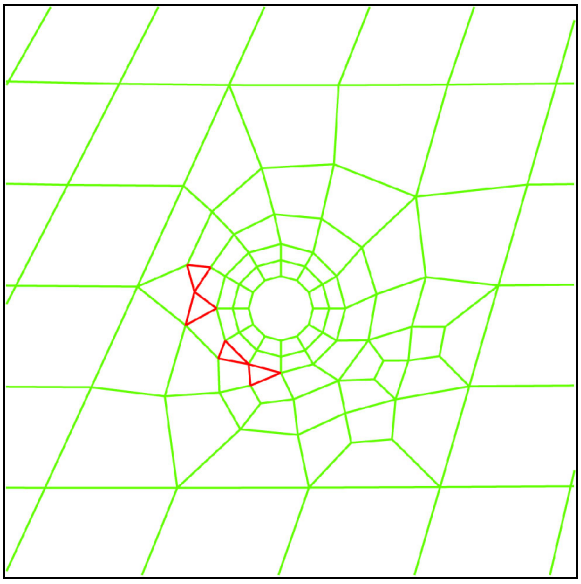


Figure 380 esquah set to 5

In this example, both **arquah** (set to 2) and **esquah** (set to 4) work together to produce the mesh on the right. This is the same otherwise, as the examples above.

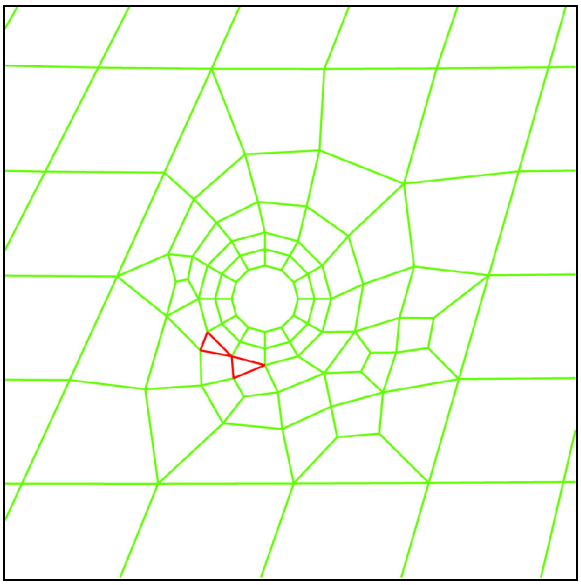


Figure 382 arquah and **esquah** set

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The following parameters can also be used to control the quality of the automatic mesh. These commands should only to be used by someone who is very familiar with this automatic quad method. There are three basic components in the automatic quads. The first is the quality of the polygons on underlying (composite) surface. The first two parameters influence this quality and the cost of the algorithm. The second component is the accuracy of the boundaries of the surface(s) being meshed. The last three parameters control how the surface(s) being meshed are decomposed into simpler nearly convex regions known here as factors.

sfasprat	value for maximum aspect ratio in surface polygons
sfmxpled	value for the maximum edge length in surface polygons
qrefnn	value for the resolution boundary fragments
qconcav	value for the maximum concavity in a factor
qresolve	value for the resolution factor
qcritang	value for the critical factor angle identifying a corner

19. Special Element Generation and Properties

Many of the commands in this section of the manual are cross sectional properties that may be unique to each element and are considered local in nature since they cannot be defined globally for the entire model. Shell element thickness can be set using the **th**, **thi**, and **thic** commands. The **ssf** and **ssfi** generate variable thickness shells based on two bounding surfaces. The outward normal direction can be defined using the **n** command. The local material orientation of blocks of shells or solids can be aligned using the **or** command. Angular rotation of the material coordinate system is limited to what is available through the global definition in the material definitions. Special geometry properties can be assigned to portions of the mesh for the NEK5000 output.

demp discrete element spheres' properties by regions

demp *region inertia flag*

where *flag* can be

0	to use mass in the definition
1	to use volume in the definition

Remarks

The mass will be calculated from the volume and density found in the material definition (see **mate**, **mt**, **mti**).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

dempi discrete element spheres' properties by progression

demp *progression inertia flag*
where *flag* can be
0 to use mass in the definition
1 to use volume in the definition

Remarks

See **demp**.

esh create a shell mesh attached to a solid mesh

esh *region material_# option* ;
where the *option* can be:
thickness constant thickness
vth *s1 s2* variable thickness
where *s1* and *s2* are two different surface numbers

Remarks

This creates shell elements from the faces of a solid part in the part phase. The shells are not actually generated until the part has ended. The shells can be seen in the merge phase.

The **vth** option flag followed by two surface definition numbers specify the thickness envelope. (i.e., to generate shell elements which have thickness defined by surfaces *s1* and *s2*). The thickness of a shell at a node is found by finding the distance in the direction normal to the shell element to both surfaces *s1* and *s2*.

eshi create a shell mesh attached to a solid mesh

eshi *progression material_# option* ;
where the *option* can be:
thickness constant thickness
vth *s1 s2* variable thickness
where *s1* and *s2* are two different surface numbers

Remarks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This creates shell elements from the faces of a solid part in the part phase. The shells are not actually generated until the part has ended. The shells can be seen in the merge phase.

The **vth** option flag followed by two surface definition numbers specify the thickness envelope. (i.e., to generate shell elements which have thickness defined by surfaces *s1* and *s2*). The thickness of a shell at a node is found by finding the distance in the direction normal to the shell element to both surfaces *s1* and *s2*.

geop geometry properties for NEK5000

geop *region type property*

where *type* can be

i for i-edges

j for j-edges

k for k-edges

where *property* can be

arc for on an arc of a circle

fsp for a face on a sphere

Remarks

This command requires that the part be generated using either quadratic or triquadratic elements. This command identify edges of a NEK5000 mesh with special curvature. The parameters of an arc of a circle passing through the 3 nodes of the edge are determined for NEK5000. When spherical curvature is available in NEK5000, then it will be required to generate the mesh with triquadratic elements so that the parameters of the sphere can be determined for each face identified by this command. Related to this command is the **nektol** command.

geopi geometry properties for NEK5000

geopi *progression type property*

where *type* can be

i for i-edges

j for j-edges

k for k-edges

where *property* can be

arc for on an arc of a circle

fsp for a face on a sphere

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

This command requires that the part be generated using either quadratic or triquadratic elements. This command identify edges of a NEK5000 mesh with special curvature. The parameters of an arc of a circle passing through the 3 nodes of the edge are determined for NEK5000. When spherical curvature is available in NEK5000, then it will be required to generate the mesh with triquadratic elements so that the parameters of the sphere can be determined for each face identified by this command. Related to this command is the **nektol** command.

nektol tolerance used by geop/geopi for NEK5000

nektol *tolerance*

Remarks

An edge in the scope of a **geop**/**geopi** command is considered an arc of a circle if the mid-node deviates from the line formed by the two end nodes by more than the tolerance specified.

n set orientation of normals on shells

n *region*

Remarks

The outward normal of shell elements is determines by the order of the nodes defining the shell and the right hand rule. The nodes can be reordered to switch the outward normal. The default outward normal is in the direction of increasing i-, j-, or k-index, respectively. If you are using an orthotropic material model, you will want to specify the normal direction, or surface orientation, yourself. The way to do it is first choose an orientation point with **orpt**. Then issue this command to set the surface direction for every shell element in the region.

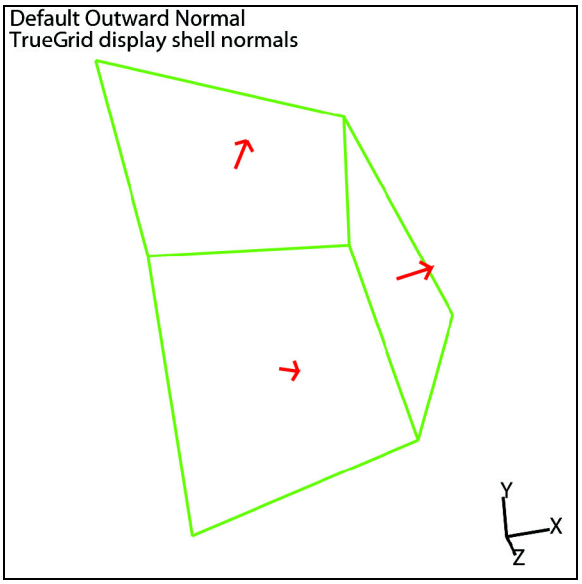


Figure 383 Default Outward Normal

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
block 1 -2;1 -2;1 -2;0 1 0 1 0 1
sd 1 sp 0 0 0 1
sfi 1 -2; 1 -2; 1 -2;sd 1
merge
co n
```

or orientation of element local coordinate axes

or *region r_axis_identifier s_axis_identifier*
where the *identifier*s must be uniquely **i**, **j**, or **k**

Remarks

This command is of importance if you are using an orthotropic or anisotropic material model. This command permutes the orientation of the r, s, and t material local coordinate axis within an element. Shell elements are a special case. If the shell element is on an i-face, for example, then only the j and k-indices can be permuted to switch the local coordinate system in the plane of the shell element. This command will preserve the outward normal orientation of the shell element (see **n** above).

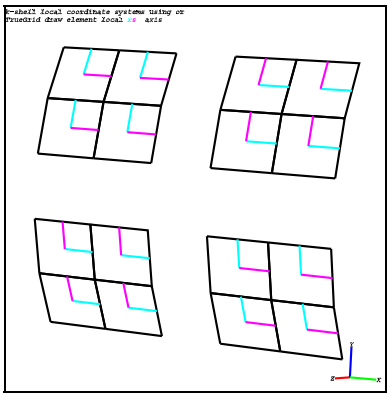


Figure 384 Material orientation

Example

```
block 1 3 0 4 6;1 3 0 4 6;-1;
      1 3 0 4 6;1 3 0 4 6;4
sd 1 cy 0 3.5 0 1 0 0 4
sfi ;; -1; sd 1
or 4 1 1 5 2 1 j i
or 1 4 1 2 5 1 j i
merge
co or rs
```

shoff offset shell reference surface

shoff *region offset*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

Move the shell reference surface from the nodal points that define the shell (Currently only available for **LSDYNA** and **NASTRAN**).

Use the **co** command with the **thic** option in the merge phase to view the shell element thickness, the location of the shell orthogonal to the reference surface of the shell, as well as the shell offset defined by this command. Since the material model shell location option (**shloc** in **LSDYNA**) and the **shoff**/**shoffi** shell offset command have similar effects on the location of the shell w.r.t. the shell reference surface, one would usually only use **shloc** or **shoff**. If both are defined, both will affect the location of the shell in the graphics. It is unknown if the sum of the two options will both affect the results in the simulation code

shoffi offset shell reference surface

shoff *progression offset*

Remarks

See **shoff** for remarks.

ssf project shell onto an interpolated surface

ssf *region surface*

where *surface* is the number of a defined surface of type **intp**.

Remarks

The surface of projection must be of type **intp**, a surface interpolated between two other defined surfaces. Shell nodes are placed along this interpolated surface. The shell thickness for each node of each shell is measured from the normal distance between the node and the two surfaces used to define the interpolated surface. All variable thickness shell elements that with a common node will have the same averaged thickness at that node.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

```
ld 1 ctbc 00 -90 90 1 1 .5 1;;
sd 1 crz 1
sd 2 sp 0 0 0 1.1
sd 3 intp 2 1 .5
block -1 3 -5;-1 3 -5;
 1 -3;-1 0 1 -1 0 1 0 1
pb 2 2 2 2 2 2 z 1.25
ssfi -1 -3; -1 -3;1 -2;3
merge co thic
```

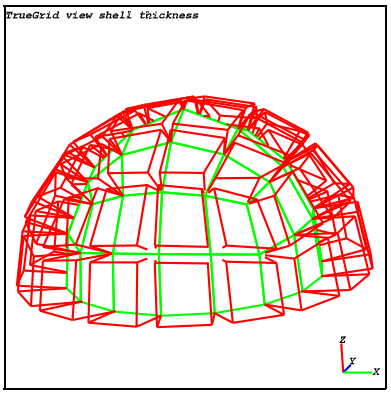


Figure 385 Variable thickness

ssfi project shell onto an interpolated surface, by progression

ssfi *progression surface*

where *surface* is the number of a defined surface of type **intp**.

Remarks

See the remarks on **ssf** above.

th thickness of shell

th *region thickness_of_shell*

Remarks

The thickness of a shell in a region of the part is set using this command. This command overrides the default thickness specified by the **thic** command.

thi thickness of shell

thi *progression thickness_of_shell*

Remarks

The thickness of a shell in a region of the part is set using this command. This command overrides the default thickness specified by the **thic** command.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

thic default shell thickness

thic *thickness*

Remarks

This command sets the default thickness for shell elements. The **th**, **thi**, **ssf**, and **ssfi** commands over ride this thickness.

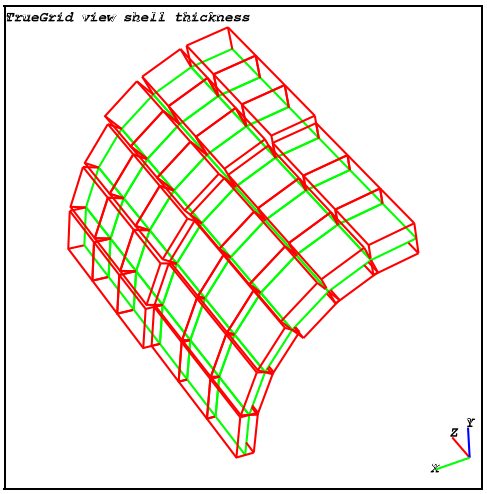


Figure 386 Shell thickness

Example

```
cylinder -1;1 4 7;1 4 7;
         1 0 45 90 1 2 3
thic .2
th 1 1 1 1 2 2 .1
th 1 2 2 1 3 3 .3
merge
co thic
```

20. Beams

Beam elements can be created in two basic ways. The first method of beam element generation extracts the needed nodes from an existing shell or brick part. This is only available within the **block** or **cylinder** part phase. The **ibm** and **ibmi** commands create beams along i-lines of the mesh, the **jbm** and **jbmi** along j-lines, and the **kbm** and **kbmi** along k-lines. This is a way to embed beam elements within a shell or brick structure. Alternatively, the material of the parent shell of brick part can be set to 0 so that the part can be generated as usual, but so that the shell or brick elements will not be saved. The nodes that are used in any of these beam commands will be saved along with the beam elements.

The second method of beam element generation uses the **bm** part. These beams are strung along a 3D curve or interpolated along a line segment. The **bm** command is only available in the merge phase.

Beam properties are defined using **bsd** and **bind**. Values defining the cross section properties including thicknesses are not affected by part transformations. In particular, the **xsca**, **ysca**, **zsca**, and **csca** commands do not scale the thicknesses of beams and shells.

ibm generate beams in the i-direction

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ibm *region #_in_j #_in_k material orientation option cross_section*

where

#_in_j is the number of columns of beam elements in the j-direction

#_in_k is the number of columns of beam elements in the k-direction

material is the material number

orientation is the option of orientation of the cross section axis

j	second axis orientation in the j-direction
k	second axis orientation in the k-direction
sd *surface_#*	second axis orientation in the normal to the surface
v *xn yn zn*	second axis orientation by the vector
none	

cross_section is the cross-section definition number assigned with **bsd**

option can be

reverse	the order of the nodes is the reverse of the default
si *sid_#*	Sliding Interface Number
vold *volume*	volume of Discrete Beam
lump *inertia*	lumped inertia
cablcid *system_#*	local coordinate system id number defined by the **lsys**
cabarea *area*	cable area
caboff *offset*	cable offset
csarea *area*	cross section area
sharea *area*	shear area of cross section
inertia *iss itt irr*	cross section moments of inertia
thickness	thickness (Hughes-Liu)
roff1 x	x-component of offset vector for first end point.
soff1 y	y-component of offset vector for first end point.
toff1 z	z-component of offset vector for first end point.
roff2 x	x-component of offset vector for last end point.
soff2 y	y-component of offset vector for last end point.
toff2 z	z-component of offset vector for last end point.
ldr1	release the x-translation constraint at first end point.
lds1	release the y-translation constraint at first end point.
ldt1	release the z-translation constraint at first end point.
lrr1	release the rotation constraint about the x-axis at first end point.
lrs1	release the rotation constraint about the y-axis at first end point.
lrt1	release the rotation constraint about the z-axis at first end point.
ldr2	release the x-translation constraint at last end point.
lds2	release the y-translation constraint at last end point.
ldt2	release the z-translation constraint at last end point.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

lrr2 release the rotation constraint about the x-axis at last end point.
lrs2 release the rotation constraint about the y-axis at last end point.
lrt2 release the rotation constraint about the z-axis at last end point.
ldr3 release the x-translation constraint at intermediate point.
lds3 release the y-translation constraint at intermediate point.
ldt3 release the z-translation constraint at intermediate point.
lrr3 release the rotation constraint about the x-axis at intermediate points.
lrs3 release the rotation constraint about the y-axis at intermediate points.
lrt3 release the rotation constraint about the z-axis at intermediate points.
theta θ orientation angle for the cross section.
warpage *n1 n2* two nodes used to determine warpage in the beam.
geom *option* method of determining curvature

where *option* can be

1 for center of curvature
2 for tangent of centroid arc
3 for bend radius
4 for arc angle

Remarks

This command is available only in the **block** or **cylinder** Part Phase. This command generates an array of beam elements conforming to the geometry and nodes of a solid or shell regions in the i-direction.

This feature is useful in generating structural elements embedded within the solid or shell region.

The local coordinate orientation can be selected in many ways or none at all.

The *v* option specifies a vector for the orientation. That vector is defined by the coordinate system. If the part is a cylinder, the vector is in the form of a radial, angular, and z-offset. Depending on the coordinates of the beam, the cylindrical vector will define a different orientation for each beam since the vector offset is made in cylindrical coordinates and then transformed to Cartesian coordinates.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Each beam element can have an additional third node used to determine the orientation of the cross-section and local material coordinate system. The neighboring beam elements can be used to select the orientation node. The options **i**, **j**, or **k** will select the node of the corresponding neighboring beam element. In each case, only two of the options are appropriate.

The **sd** option is used to orient the beam normal to a surface. The **v** option creates an orientation in a given vector direction. In the latter two cases, a new node is created for each beam, when nodes are required to orient beams. Use the **orpt** command when using the **sd** option.

To define the cross-section, use the **bsd** command.

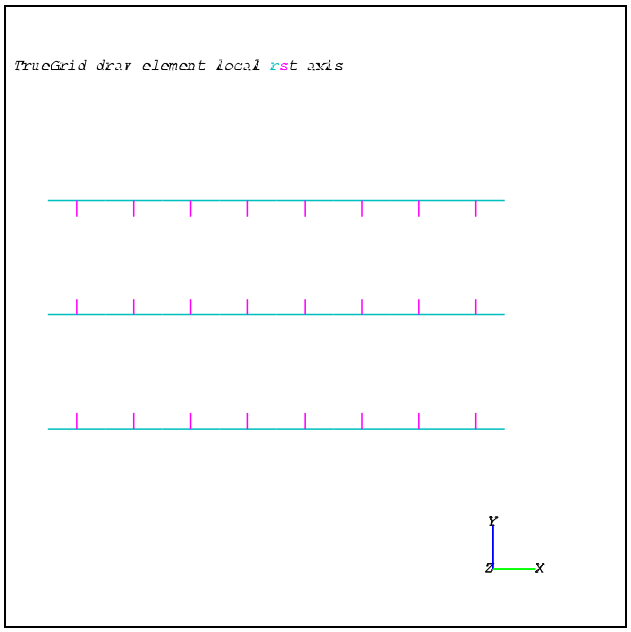


Figure 387 orientation of beam axes

A 1D sliding interface can be specified for each string of beams. Only the first sliding interface is specified. The remainder are assumed to follow in sequence. Use **sid** command to define each sliding interface.

```
sid 1 rebar;;sid 2 rebar;;sid 3 rebar;;sid 4 rebar;;
block 1 3 5;1 3 5;1 3 5;1 3 5;1 3 5;1 3 5;
ibm 1 1 1 3 3 3 2 2 1 j si 1 1 ;
```

In the above example, 4 rebar sliding interfaces are generated between 4 strings of beam elements and the corresponding brick elements, respectively. Since this is a sliding interface, there are new nodes automatically generated for the beam elements so that the beams are not coupled to the solid elements except through the sliding interface. Care should be taken not to merge these additional nodes out in the merge phase. They automatically will not be merged with their equivalent solid element nodes with the same coordinates, but they can be merged to other parts of the mesh. Use dummy sliding interfaces to control the merging.

Many of the options are designed for a specific simulation code or for a specific beam type. There is some overlap in that some of the options are used for several different types or simulation codes. Because of this complexity, you are advised to use the dialogue box to make your selection of options when using this command. The options override the properties given by the **bsd** or **bind** commands. See also **bm**, **bsd**, **bind**, and **orpt** commands.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ibmi generate beams in the i-direction by index progression

ibmi *progression #_in_j #_in_k material orientation option cross_section*

where

#_in_j is the number of columns of beam elements in the j-direction

#_in_k is the number of columns of beam elements in the k-direction

material is the material number

orientation is the option of orientation of the cross section axis

j second axis orientation in the j-direction

k second axis orientation in the k-direction

sd *surface_#* second axis orientation in the normal to the surface

v *xn yn zn* second axis orientation by the vector

none

cross_section is the cross-section definition number assigned with **bsd**

option can be

reverse	the order of the nodes is the reverse of the default
si *sid_#*	Sliding Interface Number
vold *volume*	volume of Discrete Beam
lump *inertia*	lumped inertia
cablcid *system_#*	local coordinate system id number defined by the **lsys**
cabarea *area*	cable area
caboff *offset*	cable offset
csarea *area*	cross section area
sharea *area*	shear area of cross section
inertia *iss itt irr*	cross section moments of inertia
thickness	thickness
roff1 x	x-component of offset vector for first end point.
soff1 y	y-component of offset vector for first end point.
toff1 z	z-component of offset vector for first end point.
roff2 x	x-component of offset vector for last end point.
soff2 y	y-component of offset vector for last end point.
toff2 z	z-component of offset vector for last end point.
ldr1	release the x-translation constraint at first end point.
lds1	release the y-translation constraint at first end point.
ldt1	release the z-translation constraint at first end point.
lrr1	release the rotation constraint about the x-axis at first end point.
lrs1	release the rotation constraint about the y-axis at first end point.
lrt1	release the rotation constraint about the z-axis at first end point.
ldr2	release the x-translation constraint at last end point.
lds2	release the y-translation constraint at last end point.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ldt2	release the z-translation constraint at last end point.
lrr2	release the rotation constraint about the x-axis at last end point.
lrs2	release the rotation constraint about the y-axis at last end point.
lrt2	release the rotation constraint about the z-axis at last end point.
ldr3	release the x-translation constraint at intermediate point.
lds3	release the y-translation constraint at intermediate point.
ldt3	release the z-translation constraint at intermediate point.
lrr3	release the rotation constraint about the x-axis at intermediate points.
lrs3	release the rotation constraint about the y-axis at intermediate points.
lrt3	release the rotation constraint about the z-axis at intermediate points.
theta θ	orientation angle for the cross section.
warpage *n1 n2*	two nodes used to determine warpage in the beam.
geom *option*	method of determining curvature

where *option* can be

1 for center of curvature
2 for tangent of centroid arc
3 for bend radius
4 for arc angle

Remarks

This command is exactly like **ibm** except it specifies regions of the mesh using index progressions.

Example

In this example, the block part is defined first. The default material number `1` for the part is set by the **mate** command. The beam cross section is defined by the **bsd** command for the DYNA3D code. The **ibmi** command is used for the generation of beams in the i-direction from the index progression `1 5;;;`. The number of beams in the j-direction means there are 3 columns of beam elements generated. You can also create 1 or 2 columns (**Figure 389** and **Figure 390**). You can achieve the same effect via different index progressions (**Figure 389** and **Figure 390**). This capability is important when creating beam elements from 2 faces with common a edge. It avoids duplicate beam elements on that edge. The number of elements in the k-direction is 1 (**Figure 388**). The orientation of the beam cross section axis is the j-direction. The beams are labeled by the **labels** 1D command in the Merge Phase.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
block 1 3 5 7 9;1 3 5;-1; 1 3 5 7
9;1 3 5;0;
 c block part - faces
bsd 1 sthi .1 tthi .2 ; ;
 c DYNA3D beam cross section
 c definition 1
ibmi 1 5;;; 3 1 1 j 1 ;
 c Index progression
 c 1 5;;;
 c is turned into beams
 c in the i-direction
 c Number of columns of
 c elements
 c in the j direction is 3
 c Number of rows of elements
 c in the k-direction is 1
 c The beam material number 1
 c The beam cross section axis
 c is parallel with the j-axis
 c The cross section number is 1
merge labels 1D      c beams are labeled
```

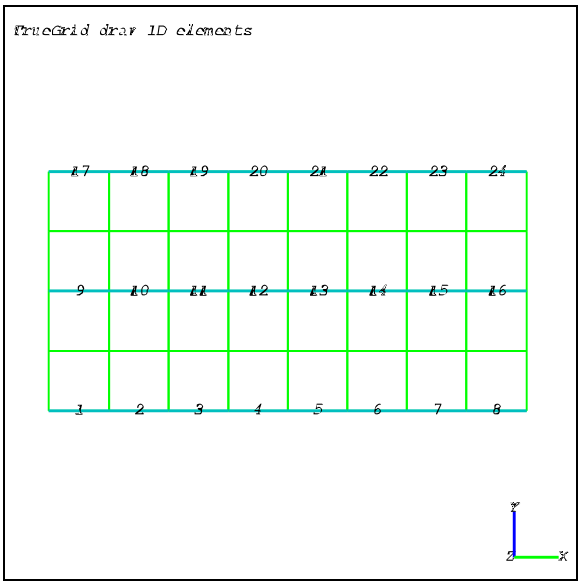


Figure 388 beams by ibmi

If the number of elements in the j-direction is changed to 1, then the middle i-line in the j-direction will be selected as a string of beams. If the number of elements in the j-direction is changed to 2, then the

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

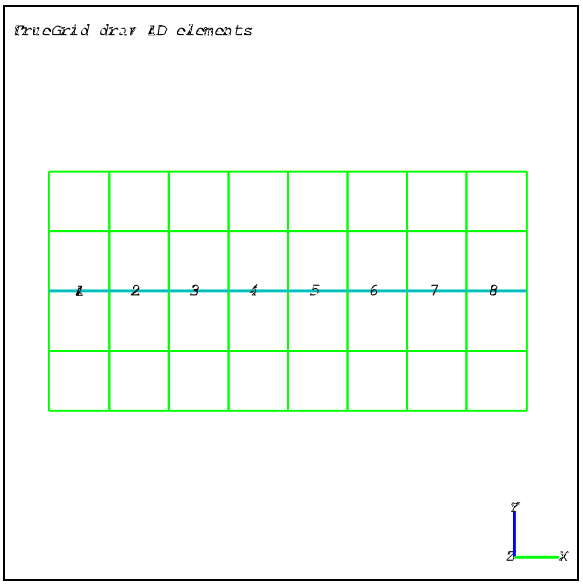


Figure 389 1 in the j-direction

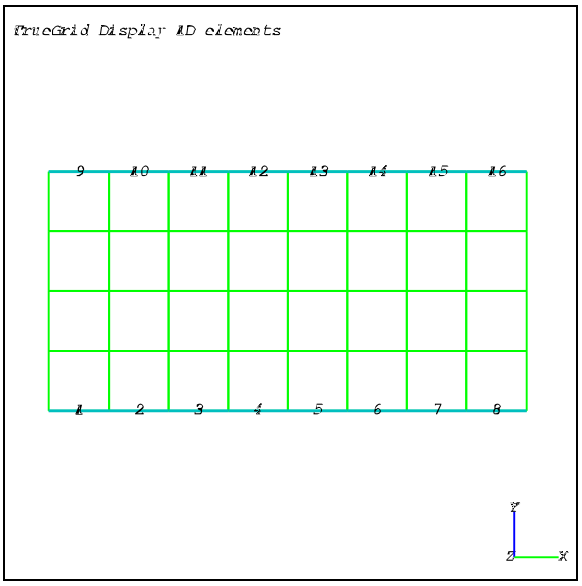


Figure 390 2 in the j-direction

two end i-lines in the j-direction are selected as strings of beams.

jbm generate beams in the j-direction

jbm *region #_in_i #_in_k material orientation option cross_section*

where

#_in_i is the number of columns of beam elements in the i-direction

#_in_k is the number of columns of beam elements in the k-direction

material is the material number

orientation is the option of orientation of the cross section axis

- **i** second axis orientation in the i-direction
- **k** second axis orientation in the k-direction
- **sd** *surface_#* second axis orientation in the normal to the surface
- **v** *xn yn zn* second axis orientation by the vector
- **none**

cross_section is the cross-section definition number assigned with **bsd**

option can be

- **reverse** the order of the nodes is the reverse of the default
- **si** *sid_#* Sliding Interface Number
- **vold** *volume* volume of Discrete Beam
- **lump** *inertia* lumped inertia
- **cablcid** *system_#* local coordinate system id number defined by the **lsys**
- **cabarea** *area* cable area

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

caboff *offset*	cable offset
csarea *area*	cross section area
sharea *area*	shear area of cross section
inertia *iss itt irr*	cross section moments of inertia
thickness	thickness
roff1 x	x-component of offset vector for first end point.
soff1 y	y-component of offset vector for first end point.
toff1 z	z-component of offset vector for first end point.
roff2 x	x-component of offset vector for last end point.
soff2 y	y-component of offset vector for last end point.
toff2 z	z-component of offset vector for last end point.
ldr1	release the x-translation constraint at first end point.
lds1	release the y-translation constraint at first end point.
ldt1	release the z-translation constraint at first end point.
lrr1	release the rotation constraint about the x-axis at first end point.
lrs1	release the rotation constraint about the y-axis at first end point.
lrt1	release the rotation constraint about the z-axis at first end point.
ldr2	release the x-translation constraint at last end point.
lds2	release the y-translation constraint at last end point.
ldt2	release the z-translation constraint at last end point.
lrr2	release the rotation constraint about the x-axis at last end point.
lrs2	release the rotation constraint about the y-axis at last end point.
lrt2	release the rotation constraint about the z-axis at last end point.
ldr3	release the x-translation constraint at intermediate point.
lds3	release the y-translation constraint at intermediate point.
ldt3	release the z-translation constraint at intermediate point.
lrr3	release the rotation constraint about the x-axis at intermediate points.
lrs3	release the rotation constraint about the y-axis at intermediate points.
lrt3	release the rotation constraint about the z-axis at intermediate points.
theta θ	orientation angle for the cross section.
warpage *n1 n2*	two nodes used to determine warpage in the beam.
geom *option*	method of determining curvature

where *option* can be

1 for center of curvature
2 for tangent of centroid arc
3 for bend radius
4 for arc angle

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

See **ibm**.

jbmi generate beams in the j-direction by index progression

jbmi *progression #_in_i #_in_k material orientation option cross_section*

where

#_in_i is the number of columns of beam elements in the i-direction

#_in_k is the number of columns of beam elements in the k-direction

material is the material number

orientation is the option of orientation of the cross section axis

i	second axis orientation in the i-direction
k	second axis orientation in the k-direction
sd *surface_#*	second axis orientation in the normal to the surface
v *xn yn zn*	second axis orientation by the vector
none	

cross_section is the cross-section definition number assigned with **bsd**

option can be

reverse	the order of the nodes is the reverse of the default
si *sid_#*	Sliding Interface Number
vold *volume*	volume of Discrete Beam
lump *inertia*	lumped inertia
cablcid *system_#*	local coordinate system id number defined by the **lsys**
cabarea *area*	cable area
caboff *offset*	cable offset
csarea *area*	cross section area
sharea *area*	shear area of cross section
inertia *iss itt irr*	cross section moments of inertia
thickness	thickness
roff1 x	x-component of offset vector for first end point.
soff1 y	y-component of offset vector for first end point.
toff1 z	z-component of offset vector for first end point.
roff2 x	x-component of offset vector for last end point.
soff2 y	y-component of offset vector for last end point.
toff2 z	z-component of offset vector for last end point.
ldr1	release the x-translation constraint at first end point.
lds1	release the y-translation constraint at first end point.
ldt1	release the z-translation constraint at first end point.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

lrr1	release the rotation constraint about the x-axis at first end point.
lrs1	release the rotation constraint about the y-axis at first end point.
lrt1	release the rotation constraint about the z-axis at first end point.
ldr2	release the x-translation constraint at last end point.
lds2	release the y-translation constraint at last end point.
ldt2	release the z-translation constraint at last end point.
lrr2	release the rotation constraint about the x-axis at last end point.
lrs2	release the rotation constraint about the y-axis at last end point.
lrt2	release the rotation constraint about the z-axis at last end point.
ldr3	release the x-translation constraint at intermediate point.
lds3	release the y-translation constraint at intermediate point.
ldt3	release the z-translation constraint at intermediate point.
lrr3	release the rotation constraint about the x-axis at intermediate points.
lrs3	release the rotation constraint about the y-axis at intermediate points.
lrt3	release the rotation constraint about the z-axis at intermediate points.
theta θ	orientation angle for the cross section.
warpage *n1 n2*	two nodes used to determine warpage in the beam.
geom *option*	method of determining curvature

where *option* can be

1 for center of curvature
2 for tangent of centroid arc
3 for bend radius
4 for arc angle

Remarks

See **ibm** above.

Example

The block part is defined at first. Default material number `1` for the part is set by the **mate** command. The beam cross section is defined by the **bsd** command for the ANSYS code. The **orpt** command sets orientation of normals out from the center of the cylinder. The **jbmi** command is used for generation of beams in the i-direction from the index progression `-1 0 -2 0 -3 0 -4 ; ; ;`. There are 4 rows of elements generated in the i-direction. The number of columns of elements in the k-direction is 1 (**Figure 391**). The orientation of the beam cross section axis is determined as parallel to the normal of the surface `1` (cylinder). The beams are labeled by the **labels** 1D command in the Merge

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Phase. The local axes of beam elements are displayed by the **co** or rst command (**Figure 392**). The command file follows:

```
block 1 3 5 7;1 3 5;-1;1 3 5 7;1 3 5;0;
  c structured block part is defined - faces only

bsd 1 ban4 area .05 ixx .003 iyy 100 izz 100
   height .3 width .2 theta 0 ; ;
      c ansys elastic beam  cross section is defined

orpt - 0 3 2
     c orientation of normals is defined from the center
     c of the cylinder surface

sd 1 cy 0 3 2 1 0 0        c surface 1 definition - cylinder
sfi 1 4;; -1; sd 1         c mesh is projected onto cylinder

jbmi -1 0 -2 0 -3 0 -4 ; ; ;1 1 1 sd 1 1 ;
 c index progression
 c -1 0 -2 0 -3 0 -4 ; ; ;
 c is turned into beams in the j-direction
 c number of columns of elements  in the i direction is 4
 c (4 edges times 1)
 c number of columns of elements  in the k-direction is 1
 c the beam material number is 1
 c the beam cross section axis is parallel with the normals
 c of the surface 1 (sd 1)
 c the cross section number is

merge

labels 1d c beams are labeled

co or rst
   c local axes rst of elements are displayed
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

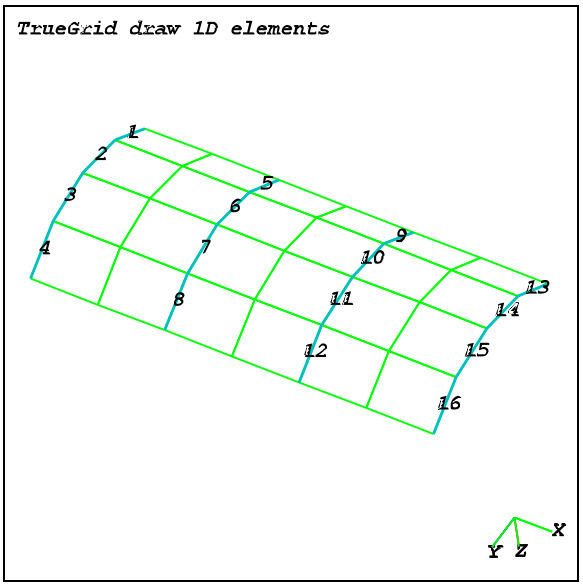


Figure 391 beams by jbmi

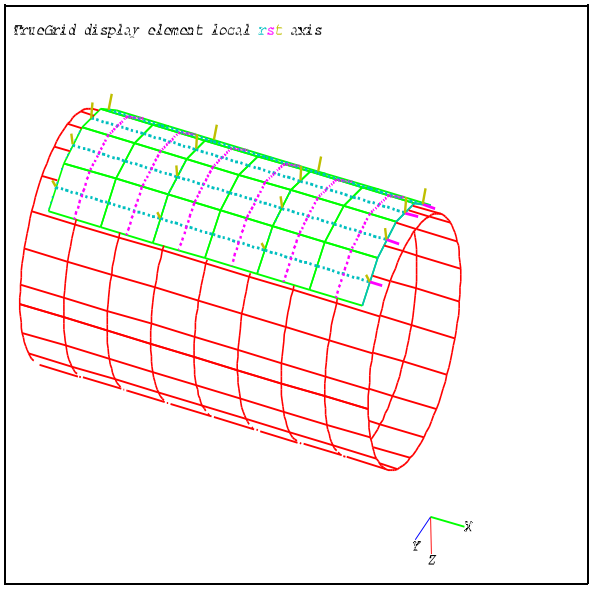


Figure 392 beams by jbmi

kbm generate beams in the k-direction

kbm *region #_in_i #_in_j material orientation option cross_section*

where

#_in_i is the number of columns of beam elements in the i-direction

#_in_j is the number of columns of beam elements in the j-direction

material is the material number

orientation is the option of orientation of the cross section axis

- **i** second axis orientation in the i-direction
- **j** second axis orientation in the j-direction
- **sd** *surface_#* second axis orientation in the normal to the surface
- **v** *xn yn zn* second axis orientation by the vector
- **none**

cross_section is the cross-section definition number assigned with **bsd**

option can be

- **reverse** the order of the nodes is the reverse of the default
- **si** *sid_#* Sliding Interface Number
- **vold** *volume* volume of Discrete Beam
- **lump** *inertia* lumped inertia
- **cablcid** *system_#* local coordinate system id number defined by the **lsys**
- **cabarea** *area* cable area

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

caboff *offset*	cable offset
csarea *area*	cross section area
sharea *area*	shear area of cross section
inertia *iss itt irr*	cross section moments of inertia
thickness	thickness
roff1 x	x-component of offset vector for first end point.
soff1 y	y-component of offset vector for first end point.
toff1 z	z-component of offset vector for first end point.
roff2 x	x-component of offset vector for last end point.
soff2 y	y-component of offset vector for last end point.
toff2 z	z-component of offset vector for last end point.
ldr1	release the x-translation constraint at first end point.
lds1	release the y-translation constraint at first end point.
ldt1	release the z-translation constraint at first end point.
lrr1	release the rotation constraint about the x-axis at first end point.
lrs1	release the rotation constraint about the y-axis at first end point.
lrt1	release the rotation constraint about the z-axis at first end point.
ldr2	release the x-translation constraint at last end point.
lds2	release the y-translation constraint at last end point.
ldt2	release the z-translation constraint at last end point.
lrr2	release the rotation constraint about the x-axis at last end point.
lrs2	release the rotation constraint about the y-axis at last end point.
lrt2	release the rotation constraint about the z-axis at last end point.
ldr3	release the x-translation constraint at intermediate point.
lds3	release the y-translation constraint at intermediate point.
ldt3	release the z-translation constraint at intermediate point.
lrr3	release the rotation constraint about the x-axis at intermediate points.
lrs3	release the rotation constraint about the y-axis at intermediate points.
lrt3	release the rotation constraint about the z-axis at intermediate points.
theta θ	orientation angle for the cross section.
warpage *n1 n2*	two nodes used to determine warpage in the beam.
geom *option*	method of determining curvature

where *option* can be

1 for center of curvature
2 for tangent of centroid arc
3 for bend radius
4 for arc angle

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

See **ibm** above.

Example

The region 1 1 2 3 2 2 of a cylinder part is turned into beams in the j-direction (4 circles) and k-direction (18 segments) by the **jbmi** and **kbm** commands, respectively. The complete mesh (**Figure 393**) and the beam rebar with the beam axes orientation (**Figure 394**) are displayed. The simplified command file follows:

```
cylinder 1 3 5;1 19;1 3 5 7;1 2 3;0 360;1 3 5 7;
     c structured cylinder mesh definition
jbmi -2; ; ;1 4 1 v 1 0 0 1 ;
 c index progression -2; ;;  is turned into beams
 c in the j-direction (4 circles)
 c number of columns of elements in the i-direction is 1
 c number of columns of elements in the k-direction is 4
 c the beam material number is 1
 c the beam cross section axis is parallel
 c with the vector (1,0,0) in cylindrical coordinates
 c the cross section number is 1
kbm 1 1 2 3 2 2 1 18 1 v 1 0 0 1 ;
 c region above is turned into beams
 c in the k-direction (18 segments)
 c number of columns of elements in the i-direction is 1
 c number of columns of elements in the j-direction is 18
 c the beam material number is 1
 c the beam cross section axis is parallel
 c with the vector (1,0,0) in cylindrical coordinates
 c the cross section number is 1
merge
set tv disp    c display of the whole mesh (bricks + beams)
labels 1d c labels of visible beams are displayed
etd 1dl on 3dl off  ; ;  c display of beams is turned on,
                         c display of bricks is turned off
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

co or rst c beam axes are displayed.

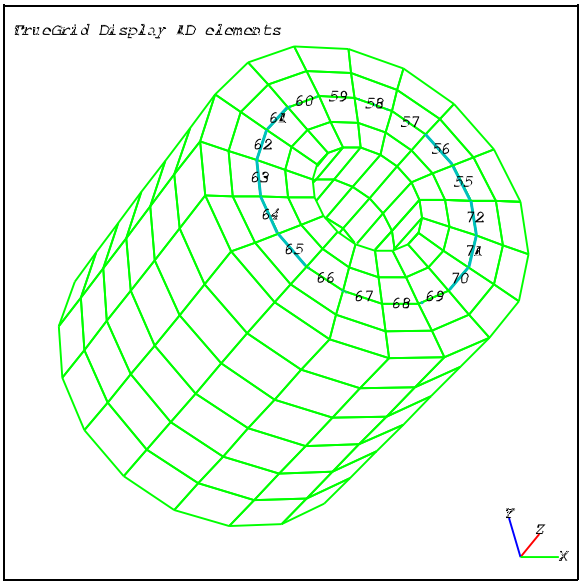


Figure 393 beam rebar inside brick mesh

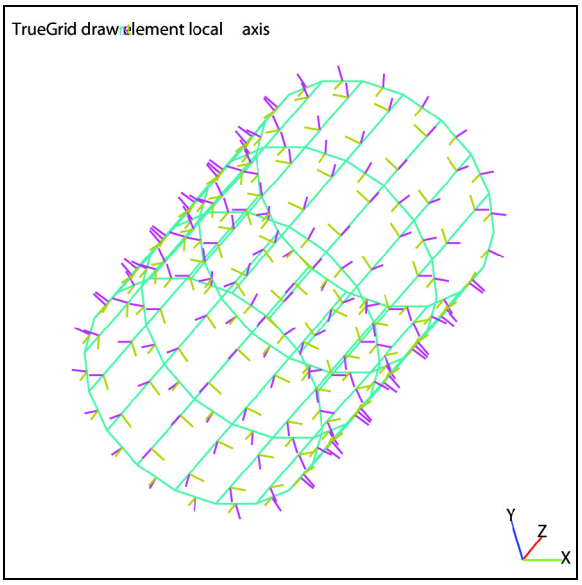


Figure 394 beam rebar inside brick mesh

kbmi generate beams in the k-direction by index progression

kbmi *progression #_in_i #_in_j material orientation option cross_section*

where

#_in_i	is the number of columns of beam elements in the i-direction	
#_in_j	is the number of columns of beam elements in the j-direction	
material	is the material number	
orientation	is the option of orientation of the cross section axis	
	i	second axis orientation in the i-direction
	j	second axis orientation in the j-direction
	sd *surface_#*	second axis orientation in the normal to the surface
	v *xn yn zn*	second axis orientation by the vector
	none	
cross_section	is the cross-section definition number assigned with **bsd**	
option can be		
	reverse	the order of the nodes is the reverse of the default
	si *sid_#*	Sliding Interface Number
	vold *volume*	volume of Discrete Beam
	lump *inertia*	lumped inertia
	cablcid *system_#*	local coordinate system id number defined by the **lsys**

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

cabarea *area*	cable area
caboff *offset*	cable offset
csarea *area*	cross section area
sharea *area*	shear area of cross section
inertia *iss itt irr*	cross section moments of inertia
thickness	thickness
roff1 x	x-component of offset vector for first end point.
soff1 y	y-component of offset vector for first end point.
toff1 z	z-component of offset vector for first end point.
roff2 x	x-component of offset vector for last end point.
soff2 y	y-component of offset vector for last end point.
toff2 z	z-component of offset vector for last end point.
ldr1	release the x-translation constraint at first end point.
lds1	release the y-translation constraint at first end point.
ldt1	release the z-translation constraint at first end point.
lrr1	release the rotation constraint about the x-axis at first end point.
lrs1	release the rotation constraint about the y-axis at first end point.
lrt1	release the rotation constraint about the z-axis at first end point.
ldr2	release the x-translation constraint at last end point.
lds2	release the y-translation constraint at last end point.
ldt2	release the z-translation constraint at last end point.
lrr2	release the rotation constraint about the x-axis at last end point.
lrs2	release the rotation constraint about the y-axis at last end point.
lrt2	release the rotation constraint about the z-axis at last end point.
ldr3	release the x-translation constraint at intermediate point.
lds3	release the y-translation constraint at intermediate point.
ldt3	release the z-translation constraint at intermediate point.
lrr3	release the rotation constraint about the x-axis at intermediate points.
lrs3	release the rotation constraint about the y-axis at intermediate points.
lrt3	release the rotation constraint about the z-axis at intermediate points.
theta θ	orientation angle for the cross section.
warpage *n1 n2*	two nodes used to determine warpage in the beam.
geom *option*	method of determining curvature

where *option* can be

1 for center of curvature

2 for tangent of centroid arc

3 for bend radius

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

4 for arc angle

Remarks

See **ibm** above.

Example

This example shows some of the difficulties in generating rebar with 1D slide lines through the concrete. It is complicated by a butterfly topology for the surrounding concrete. Here are the key points.

1. The i-beams on the j-faces include the edges of those faces. Do not create similar i-beams along the k-faces because they will be merged. The double beams along the butterfly seams will continue to exist and remain undetected. The **info** command can be used to determine the total number of beam elements. However, the graphics will be of little use in detecting duplicate beams as seen in 397.

2. Choose different materials for each of the beam sets so they can be viewed independently. The different beam commands are color coded in 395. After you are certain that you have what you want, then go back and combine the beam materials if you wish.

3. Carefully count the number of sliding interfaces needed for this construction. Also check the table of sliding interfaces in the merge phase after merging. Make sure you agree with the stats.

4. A dummy sliding interface is needed to avoid the merging of the i-beams along the edges of the j-faces with the merging edges from the k-faces.

5. Additional dummy sliding interfaces will be needed to avoid merging of beam nodes. Without special care, beam nodes will be merged as shown in 396. The interactive selection of nodes for a node set is very useful here. It is not, however, parametric. If you change the mesh size, these sets must be selected again.

```
c  Set mrgrb to 0 if the rebar nodes should be merged together
c  Set mrgrb to 1 if the vertical (i-beams) should not be
c  merged to the beams forming circles
para mrgrb 1;
c  Pillar material.
dynamats 1 1 rho 2300 e 6.205e10 pr 0.21;
c  Rebar material - diferent material numbers for graphics.
dynamats 2 3 rho 7850 beam elfom bs e 2.05e11 pr 0.3 sigy 2.0e8;
dynamats 3 3 rho 7850 beam elfom bs e 2.05e11 pr 0.3 sigy 2.0e8;
dynamats 4 3 rho 7850 beam elfom bs e 2.05e11 pr 0.3 sigy 2.0e8;
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
c  52 seperate strings of beams forming 1D slide lines.
sid  1 rebar;sid  2 rebar;sid  3 rebar;
sid  4 rebar;sid  5 rebar;sid  6 rebar;
sid  7 rebar;sid  8 rebar;sid  9 rebar;
sid 10 rebar;sid 11 rebar;sid 12 rebar;
sid 13 rebar;sid 14 rebar;sid 15 rebar;
sid 16 rebar;sid 17 rebar;sid 18 rebar;
sid 19 rebar;sid 20 rebar;sid 21 rebar;
sid 22 rebar;sid 23 rebar;sid 24 rebar;
sid 25 rebar;sid 26 rebar;sid 27 rebar;
sid 28 rebar;sid 29 rebar;sid 30 rebar;
sid 31 rebar;sid 32 rebar;sid 33 rebar;
sid 34 rebar;sid 35 rebar;sid 36 rebar;
sid 37 rebar;sid 38 rebar;sid 39 rebar;
sid 40 rebar;sid 41 rebar;sid 42 rebar;
sid 43 rebar;sid 44 rebar;sid 45 rebar;
sid 46 rebar;sid 47 rebar;sid 48 rebar;
sid 49 rebar;sid 50 rebar;sid 51 rebar;
sid 52 rebar;
c Avoiding merging between rebars
sid 53 dummy;
if(%mrgrb.ne.1)then
 sid 54 dummy; sid 55 dummy;
endif
c  Beam cross section definition.
bsd 1 sthi 0.01 tthi .01 ; ;
c  Inner and outer cylinders of the column.
sd 1 cy 0 .25 .25 1 0 0 .25
sd 2 cy 0 .25 .25 1 0 0 .2
c  One part with both concrete solid and rebar beam elements.
block 1 3 13 15;1 3 5 9 11 13;1 3 5 9 11 13;
 0 .2 .8 1 .15 .15 .15 .35 .35 .35 .15 .15 .15 .35 .35 .35
c  Butterfly the corners to get a good mesh.
dei ; 1 3 0 4 6; 1 3 0 4 6;
c  Project to the two cylinders
sfi ; -1 -6; -1 -6;sd 1
sfi ; -2 -5; -2 -5;sd 2
c  Beams in the i-direction
ibmi 1 4;-2 -5;3 4;1 3 2 j si 1 1 ;
c  Mid-plane beams in the orthogonal direction
ibmi 1 4;3 4;-2 -5;1 1 2 j si 7 1 ;
c  Beams in the k-direction
```

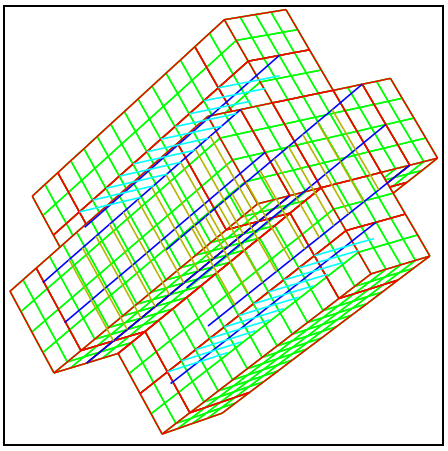


Figure 395 Part Topology

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
kbmi 2 3;-2 0 -5;3 4;11 1 3 i si 9 1 ;
c  Beams in the j-direction
jbmi 2 3;3 4;-2 0 -5;11 1 4 i si 31 1 ;
c  Special care is needed to avoid merging at the butterfly.
nseti 1 4;-3 0 -4;-2 0 -5;= s1
mate 1
endpart
merge
if(%mrgrb.eq.1)then
 nset s2 = l 1576:1915;
 si nset s1 53 m
 si nset s2 53 s
else
 nset s2 = l 1576:1695;
 nset s3 = l 1696:1915;
 si nset s1 53 m si nset s2 53 s si nset s2 54 m
 si nset s3 54 s si nset s3 55 m si nset s1 55 s
endif
stp .001 c Merge the components
```

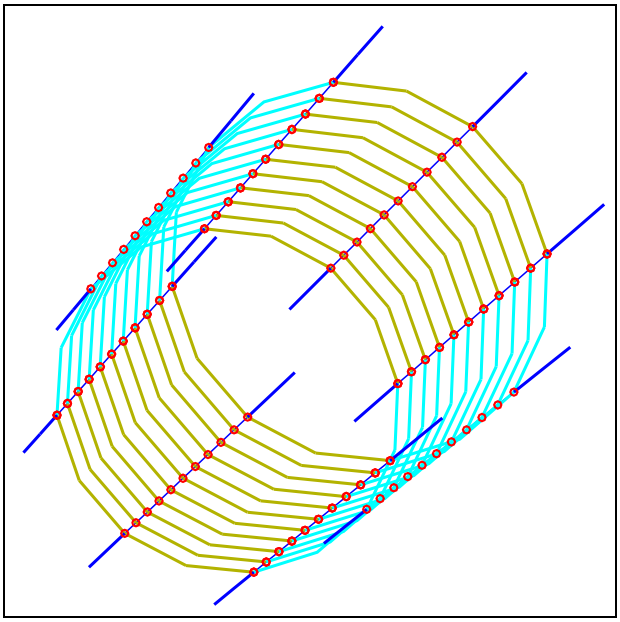


Figure 396 Merged Beams

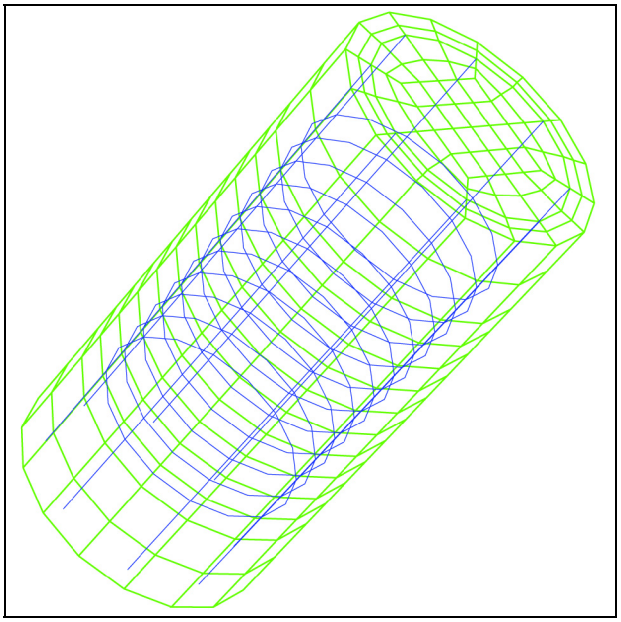


Figure 397 Rebar in Concrete

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

21. Diagnostics Commands

mea choose a way to measure mesh quality

mea *region option*

where

option can be:

volume	to integrate the volume of each element
avolume	to integrate the absolute volume
jacobian	to compute the determinant of the Jacobian
orthogon	to measure deviations from orthogonality (90 degrees)
smallest	for the smallest dimension of each element
pointvol	to calculate the volume with a one point integration formula
aspect	to calculate the aspect ratio for each element
warp	to measure the angle between opposite corners of each element face
dvi	measure the change in volume in the i-direction
dvj	measure the change in volume in the j-direction
dvk	measure the change in volume in the k-direction
dli	measure the change in edge length in the i-direction
dlj	measure the change in edge length in the j-direction
dlk	measure the change in edge length in the k-direction
stiffn	measure the stiffness (find the condition number) of the Jacobian
commands	check regions of commands in the history table
subvol	volume of sections of elements

Remarks

A histogram is drawn to show the profile of the mesh according to the selected measure. The abscissa is the measure and the ordinate is the number of elements when there is one measurement per element or element segments when there are several measurements per element. The range of the measurement, the mean, and the standard deviation is written to the save file and it is displayed in the text window during an interactive session. These 4 values are assigned to the minmea, maxmea, mean, and standev automatic parameters, respectively.

This measure can detect invalid elements if a tolerance is specified using one of the merging commands (**t**, **tp**, **stp**). This tolerance is also used to identify the element geometry (hex, tet, wedge, pyramid, quad, or triangle). Many of the options depend on a shape function which is different for each type of element geometry. The order of the element (linear, quadratic, and triquadratic) also determines the shape function used in the measure. There are 14 different shape functions based on the element types generated by **True*Grid*®**. For more details on the mathematics, see "Application of An *a priori*

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Jacobian-based Error Estimate Metric to the Accuracy Assessment of 3D Finite Element Simulations" by Robert B. Rainsberger, Jeffrey T. Fong, and Pedro V. Marcal published in the "Proceedings of the ASME Pressure Vessels and Piping Conference", PVP2018-84784, July 15-20, 2018, Prague, Czech Republic. See the **vigq** command to change the number of Gaussian quadrature points from the default of 2.

The **volume** option integrates the volume of a brick element using the appropriate shape function to estimate the volume. It is possible for the volume to be negative in some regions of the element; in that case the net volume will not be realistic. Shell elements are given thickness and the same method is then used to calculate the volume. If the shell element was not assigned a thickness, then the default of 1 is used.

The **avolume** option has the advantage that it is not affected by negative volumes since the absolute volume is integrated. Shells are given thickness as for the volume option above and then treated like a brick element.

The **pointvolume** option approximates the volume of an element using the Jacobian at a single point in the center of the element. The shell elements are given thickness and treated the same as bricks (see above).

The **orthogonal** option measures all angles at all corners of a quad face of a brick element. It then graphs the deviation from 90 degrees. Each quad shell element is measured at each of the four corners.

The **Jacobian** option measures the distortion of each element by sampling the Jacobian matrix of the appropriate shape function. In order to graph this data, the Jacobian matrix is reduced to a single number by first determining the eigenvalues of the matrix. The eigenvalue whose modulus is found between the other two is used to scale the Jacobian matrix. The matrix is divided by the cube of this modulus. This factors out the scale of the element. The determinant of the resulting matrix is graphed. Shell elements are given thickness to make this measurement.

The **stiffn** options measures the stiffness or condition number of the Jacobian using the appropriate shape function. Shell elements are given thickness to make this measurement.

The **smallest** option determines the smallest dimension of an element as the measurement.

The **warp** option measures the angle between the normals at opposing nodes of each quad face.

The **dvi** option measures the ratio of volumes of consecutive elements along every thread of elements in the i-direction.

The **dvj** option measures the ratio of volumes of consecutive elements along every thread of elements

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

in the j-direction.

The **dvk** option measures the ratio of volumes of consecutive elements along every thread of elements in the k-direction.

The **dli** option measures the ratio of edge lengths of consecutive elements along every thread of elements in the i-direction.

The **dlj** option measures the ratio of edge lengths of consecutive elements along every thread of elements in the j-direction.

The **dlk** option measures the ratio of edge lengths of consecutive elements along every thread of elements in the k-direction.

The **aspect** ratio is defined as the ratio of the largest diagonal to the smallest diagonal of an element. If the largest diagonal is zero, then the ratio is set to zero. If the smallest diagonal is zero, the ratio is set to a very large constant.

The **commands** option determines when certain commands in the history table are disabled because they are applied to a deleted region. This includes commands that move, smooth, change nodal distributions of, assign block and transition boundaries of, attachment to curves and edges of, and assign boundary constraints of the selected region(s) of the mesh.

The **subvol** option displays the minimum and maximum element sample volumes used to calculate the total volume of an element. This makes it easy to identify those elements with regions of negative volume.

With the **elm** and **elmoff** commands, you can see the locations in the mesh of the most interesting elements; e.g. you can use **measure** to measure volume and then **elm** to highlight the biggest elements.

meai choose a way to measure mesh quality

meai progression *option*

where

option can be:

volume	to integrate the volume of each element
avolume	to integrate the absolute volume
jacobian	to compute the determinant of the Jacobian
orthogon	to measure deviations from orthogonality (90 degrees)
smallest	for the smallest dimension of each element

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

pointvol	to calculate the volume with a one point integration formula
aspect	to calculate the aspect ratio for each element
warp	to measure the angle between opposite corners of each element face
stiffn	measure the stiffness (find the condition number) of the Jacobian
commands	check regions of commands in the history table
subvol	volume of sections of elements

Remarks

See **mea** for remarks.

vigq quadrature rule for mass calculations

vigq *n*

where *n* is the number of Gaussian quadrature points (up tp 5) used in the Jacobian based options of the **mea**/**meai** commands. This includes **volume**, **avolume**, **Jacobian**, **stiffn**, **dvi**, **dvj**, **dvk**, and **subvol**.

Remarks

The default is 2.

22. Parts Commands

cycorsy frame of reference for cylinder part

cycorsy *trans* ;

where $trans_i$ is a left-to-right product of the following basic operations:

mx *x_offset*	to translate in the x direction
my *y_offset*	to translate in the y direction
mz *z_offset*	to translate in the z direction
v *x_offset y_offset z_offset*	to translate by a vector
scv *xn yn zn offset*	to translate a given distance along a vector
dv $x_1\ y_1\ z_1\ x_2\ y_2\ z_2$	to translate by a vector given by two points
rx *theta*	to rotate about the x axis
ry *theta*	to rotate about the y axis
rz *theta*	to rotate about the z axis
raxis *angle x0 y0 z0 xn yn zn*	axis of rotation

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

rxy to reflect about the x-y plane
ryz to reflect about the y-z plane
rzx to reflect about the z-x plane
tf *origin x-axis y-axis*
where each of the arguments consist of a coordinate type followed by coordinate information:
rt *x y z* Cartesian coordinates
cy *rho theta z* cylindrical coordinates
sp *rho theta phi* spherical coordinates
pt *c.i* label of a labeled point from a 3D curve
pt *s.i.j* label of a labeled point from a surface
ftf *1st_origin 1st_x-axis 1st_y-axis 2nd_origin 2nd_x-axis 2nd_y-axis*
where each of the arguments consist of a coordinate type followed by coordinate information:
rt *x y z* Cartesian coordinates
cy *rho theta z* cylindrical coordinates
sp *rho theta phi* spherical coordinates
pt *c.i* label of a labeled point from a 3D curve
pt *s.i.j* label of a labeled point from a surface
inv invert the present transformation)

Remarks

The frame of reference for the **cylinder** part can be changed from the default. The default is where the pole in the cylindrical coordinate system aligns with the z-axis of the global Cartesian coordinate system. This new command is followed by a sequence of rigid body operators. These are translations, rotations, and reflections. As before, the part cannot cross over the pole - it can only go around it. If the part must cross over the pole, then the **cylinder** part is the wrong part. Use the Cartesian **block** part.

This command can be issued anytime after a **cylinder** command. Care is needed here because if other commands have already been issued, they may behave differently when this command is issued. This command can be issued any number of times to allow for experimentation. It is not cumulative.

endpart complete the part and add it to the data base

endpart (no arguments)

Remarks

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

This command can be used to complete a part and add it to the database. This command is automatically generated when you issue a subsequent **control**, **merge**, **block**, **blude**, or **cylinder** command. Once one of these commands is issued, the part is considered complete and no additional modifications can be made to the part. If it is necessary to make additional modifications to the part after one of these commands have been issued, you must end the session, change the name of the tsave file, edit this file by inserting the **interrupt** command where additional commands are needed, and run with this file as the command file.

savepart save all part data in a parts data base

savepart *filename*

Remarks

This command is used to save all data for a part so that a part can be modified at a later time. However, all of the machinery to do this is not yet completed. The only feature available at this time is the ability to use a block boundary interface (see **getbb**) after the part has been saved using this command.

23. Replication of Parts

Coordinate transformations are used to translate, scale, and rotate an object in a local coordinate system to the global coordinate system. A local coordinate system is a frame of reference chosen to define an object or component of the larger model. A local coordinate system is almost always a matter of convenience. The global coordinate system refers to the frame of reference used to create the complete model.

In many cases, a component is duplicated many times. Each duplicate component must be transformed or placed into its proper location within the global coordinate system. For this reason, the coordinate system transformation and the part duplication commands are closely coupled.

In all cases, a coordinate transformation is composed of a sequence of basic operations. Each basic operation is given by a keyword possibly followed by some parameters. Each basic operation is performed in order from left to right. This ordering of the basic operations is sometimes referred to as a product or composition of basic operations. The composition of the basic operations is referred to as a coordinate transformation.

It can be difficult to think of a complex transformation in three dimensions. You can simplify this by thinking of the object already in the global coordinate system. Then build the transformation, one operation at a time until you have moved, rotated, and scaled it to the proper position and size.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

You can use combinations of these transformations in many ways: local coordinate transformations (**lct**), global coordinate transformations (**gct**), level transformations (**lev**), surface definitions (**sd**), 3D curve definitions (**curd**), **IGES** data (**iges**, **igessd**, **igespd**, **nurbsd**, **igescd**), local constraints (**lsys**), initial part transformations (**tr**), and block boundary interfaces (**bb**, **trbb**). In all but the first three cases you use only one transformation; thus you do not need the **repe**, **save**, and **last** operators.

The way the local **lrep**, global **grep**, and level **pslv/pplv** replication commands are used is that you begin by defining local **lct**, global **gct**, and level **levct** transformations respectively, and then invoke them to replicate parts.

The simplest way to apply transformations and replications is locally (**lct**). If the local commands solve your problem easily, there is no need to learn how to use the others. To define local coordinate transformations, use the **lct** command. Then you may use the **lrep** command to specify replications of a part. Of course, the **lct** and **lrep** commands normally should appear within the scope of the same part. However, if several parts in sequence use the same local coordinate transformations, you only need to define them in the first part and then use them (**lrep**) in each part.

Global coordinate transformations are similar to local transformations. Define global transformations with **gct** and use them to replicate a part with **grep**. You also can combine global and local transformations within a part, resulting in a product of the transformations. Moreover, you can use global transformations to define level transformations.

Level transformations are used to replicate parts much like local and global transformations. But they are more complicated and flexible. You may nest one set of level transformations within another, or global or local transformations within level transformations. Nesting means that all possible combinations of the specified transformations will be applied. This lets you create a tremendous number of transformed copies of a part with only a few commands.

You define a set of level transformations with the **lev** command. At that time you give it a number so that you may apply it anyplace thereafter. The **pslv** and **pplv** commands define the scope of a level. All of the level's transformations are applied to all parts in its scope.

lrep local replication of a part

lrep *list_local_transform_# ;*

where

list_local_transform_#	list of sequential numbers of a transformations defined by the last **lct** command for the current part

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

Each transformation identified in the list of local transformations is applied to a duplicate of the current part. The original part does *not* get added to the model by default. However, a sequence number of 0 in the **lrep** transformation list means to include the original part without a transformation.

By default, all replicates of the part will have the same material number. But you can have the material numbers change by a constant for each local replicate of the part. The material number of a replicate will be computed as

(original material number) + (local material increment) * (sequence number of replicate)

The **lmi** command sets the local material increment.

Similarly, you may increment sliding interface numbers with a local sliding interface increment, set by the **lsii** command and you may increment joint numbers with a joint command increment, set by the **inc** option of the **jt** command.

Up to 300 transformations can be listed in the **lrep** command.

If the **grep** command is also used, the result is a product of the two lists of transformations. For example, suppose the **lct** command has 3 transformations:

```
lct 3 rz 90; rz 180; rz 270; lrep 0 1 2 3;
```

This produces 4 copies of the part, including the original untransformed part. Now also suppose that the gct has 1 transformation:

```
gc t 1 mz 10; grep 0 1;
```

Then the result is 8 replications, 4 local times 2 global. This is equivalent to:

```
lct 7 rz 90;rz 180;rz270;mz 10;rz 90 mz 10;rz 180 mz 10;rz 270 mz
10; lrep 0:7;
```

The replicated parts can only be viewed in the Merge Phase.

Example

In this example, a pole is conveniently built with the z-axis the axis of symmetry. This part is then positioned by rotation and translation (ry 15 my 1.5) at first. Then it is replicated two times by rotation

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

(rz 120) to form a tripod.

```
title poles - using lct
block 1 4;1 4;1 51;-1 1 -1 1 -5 40 c Block part definition.
sfi -1 -2; -1 -2;;cy 0 0 0 0 0 1 1
     c Outer faces of the mesh are projected
     c onto a cylinder given by a point on the axis
     c of rotation (0,0,0), vector of axis of rotation
     c (0,0,1) and radius(r=1)
lct 3 ry 15 my 1.5;last rz 120;last rz 120;
     c Definition of the local transformation.
     c The pole is rotated by 15 degrees around the y-axis
     c and moved in the y-direction for 1.5 unit
     c (ry 15 my 1.5). Then it is rotated 2 times around
     c the z-axis (rz 120).
lrep 1 2 3;    c The local replication of the part
     c is performed by invoking local transformations 1
     c (ry 15 my 1.5), 2(rz 120) and 3(rz 120)
merge
     c The results of replication are visible in the Merge Phase
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

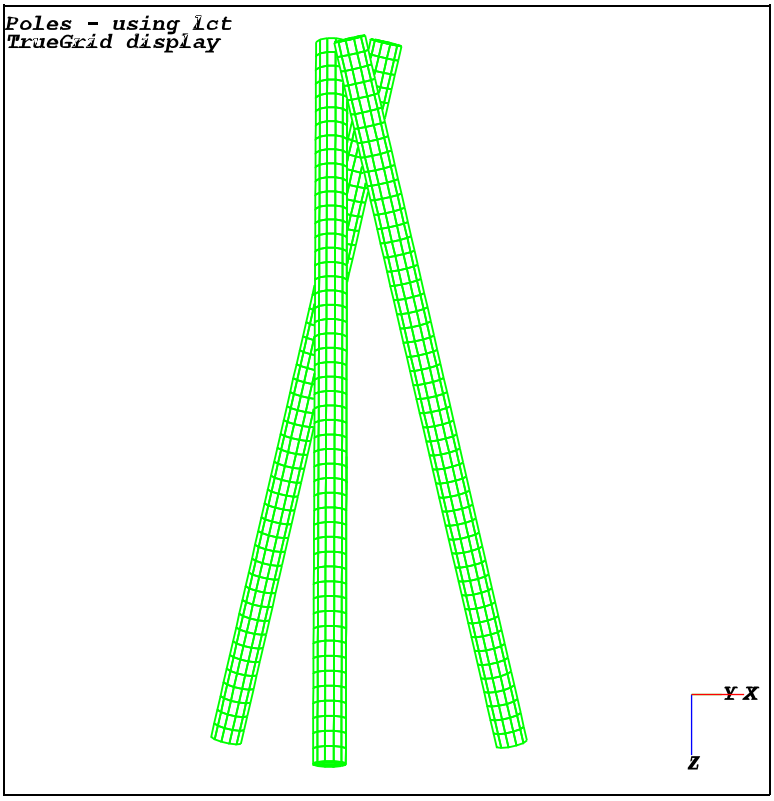


Figure 398 Three copies of a single part

grep global replication of a part

grep *list_local_transform_# ;*

where

transform_# number of a transformation defined by the last **gct** command for the current part

Remarks

Each transformation identified in the list of global transformations is applied to a duplicate of the current part. The original part does *not* get added to the model by default. However, a sequence number of 0 in the **grep** transformation list means to include the original part without a transformation.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

By default, all replicates of the part will have the same material number. But you can have the material numbers change by a constant for each global replicate of the part. The material number of a replicate will be computed as

(original material number) + (global material increment) * (sequence number of replicate)

The **gmi** command sets the local material increment.

Similarly, you may increment sliding interface numbers with a local sliding interface increment, set by the **gsii** command and you may increment joint numbers with a joint command increment, set by the **inc** option of the **jt** command.

Up to 300 transformations can be listed in the **grep** command.

The most useful application of global replication is to decompose a problem into a two-level hierarchy. For example, an easy way to model a brick wall is to define a single part to represent a brick. Then local coordinate transformations can make many copies of the brick to form a row of bricks. Then global coordinate transformations can form copies of the row of bricks, stacking each new row of bricks onto another to form the wall.

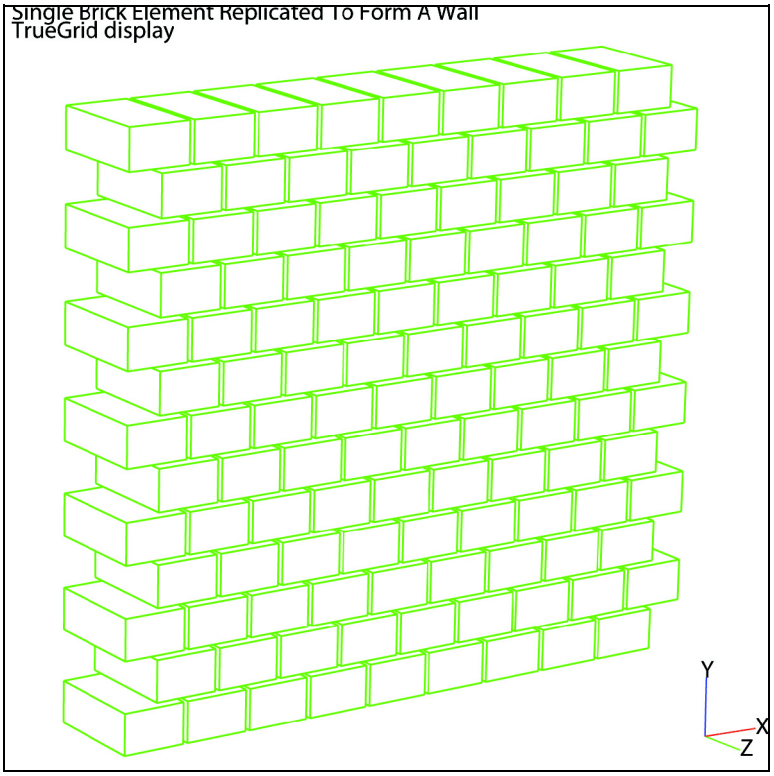


Figure 399 Product of local and global replications

Examples

```
grep 0 5 3 ;
lrep 0 1 ;
```

These two commands specify six copies of the present part. They are:

1) original part
2) local transformation number 1 applied to a copy
3) global transformation number 5 applied to a copy
4) local transformation number 1 applied to a copy and then global transformation number 5 is applied
5) global transformation number 3 applied to a copy

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

6) local transformation number 1 applied to a copy and then global transformation number 3 is applied

This next example builds a row of bricks using local coordinate transformations. Then the row is replicated to form a wall.

```
gct 12 mx 1.5 my  2;my  4; mx 1.5 my  6;
          my  8; mx 1.5 my 10;my 12;
         mx 1.5 my 14;my 16; mx 1.5 my 18;
          my 20; mx 1.5 my 22;my 24;
block 1 2;1 2;1 2;0 2.8 0 1.8 0 4.8
lct 19 mx 3;repe 19;
lrep 0 1 2 3 4 5 6 7 8;
grep 0 1 2 3 4 5 6 7 8 9 10 11 12;
endpart
```

24. Merging of Parts

In the Merge Phase, nodes that are close to one another are merged into a single node. Merge commands allow you to define how close is close. All tolerances are in absolute distances. There are commands for specifying tolerances for the general merging of all nodes over all parts or just nodes on the exterior faces of the mesh. There are commands for specifying the tolerances for the special merging of nodes between parts or within a part. These special tolerances override the general ones. If no tolerance commands are specified, then no merging is done. However, the Merge Phase must be entered in order to build the node map which is used to generate the output.

Invocation of a tolerance command (**t**, **tp**, **st**, **stp**) within the Merge Phase causes an immediate merging of nodes. These commands can also be invoked within any phases; when the Merge Phase is entered, those tolerance commands are immediately executed or re-executed as the case may be. The merge process is always performed on the nodes in their original (prior to any merging) state. Merging is not cumulative. If you leave the Merge Phase and reenter it, all merging is recalculated with what ever new parts that have been added. This lets you interactively experiment with merging and tolerances. Setting a tolerance to a negative value is an easy way to restore the nodes to their original states. Graphical displays of the mesh in the Merge Phase always reflect the results of any merging.

Nodes are merged depending on the distance between them. If a node lies within a tolerance distance of more than one other node, then it is merged with the closest one. When merging several nodes into one node, the first-defined node survives. This can be overridden by the **bptol** command. Nodes within a joint and across the two sides of a sliding surface are not merged. When the first merging of nodes occurs, a sliding interface table is calculated which is used in the merging process. This table is written to the screen and to the save file and is intended as diagnostics. The following is a sample

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

of that table:

```
                SLIDING INTERFACE SUMMARY
Surf    S-node    S-lseg    S-qseg    M-node    M-lseg    M-qseg
   1       105        84         0       468       418         0
   2       232         0        52       468       418         0
   3       221         0         0       390       304         0
   4       221         0         0       390       304         0
   5       158         0         0       120        88         0
   6       158        30        30       120        88         0
   7       204       102         0       204       102         0
   8       232         0        52        90        52         0
   9       101        18        18       161       132         0
  10       101        18        18       161       132         0
  11       548       120       120      3216         0      1056
  12       133        84         0       161       132         0
  13       133        84         0       161       132         0
  14       308       240         0      3216         0      1056
```

This table is organized by the sliding interface number on the right. Columns 2, 3, and 4 are datum pertaining to the slave side on the interface; columns 5, 6, and 7 to the master side. Columns 2 and 5 (`S-node` and `M-node`) are node counts. Columns 3 and 6 (`S-lseg` and `M-lseg`) are linear face counts, and columns 4 and 7 (`S-qseg` and `M-qseg`) are quadratic face counts.

A table of merged nodes is always written after the **tp** or **stp** commands are executed.

```
                MERGED NODES SUMMARY
  12 nodes merged between parts        1 and        2
  16 nodes merged between parts        2 and        2
  12 nodes merged between parts        1 and        3
  16 nodes merged between parts        3 and        3
 216 nodes merged between parts        4 and        4
  30 nodes merged between parts        7 and        7
  88 nodes merged between parts        8 and        8
 390 nodes were deleted by tolerancing
```

Up through 4000 parts can be merged under general tolerancing (i.e. no use of the **ptol** or **bptol** commands). 1000 parts can be merged under special tolerancing (**ptol** and **bptol**).

The following is a common error to avoid. Suppose you create three parts that meet as shown in 400 and 401. Then define a sliding interface between parts 1 and 2 and also between parts 1 and 3. No nodes will be merged between parts 1 and 2 and between parts 1 and 3. However, nodes can be

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

merged between parts 2 and 3. Sometimes you need to look closely in the graphics or carefully check the Merged Nodes Summary to detect this error. To fix this error, if indeed it is an error, use a dummy sliding interface between parts 2 and 3 to force no merging between those parts. Alternatively, use the **bptol** command with a negative number to avoid merging between those parts. You should also consider extending both interfaces 1 and 2 across to parts 3 and 2, respectively, because they may come in contact. This is an ambiguous situation since there are equally plausible situations where parts 2 and 3 should be merged together.

```
sid 1 sv;
sid 2 sv;
block 1 3;1 3;1 3;
     1 2 1 2 1 2
sii -2;;;1 s;
sii ;-2;;2 s;
block 1 3;1 3;1 3;
     2.1 3 1 2 1 2
sii -1;;;1 m;
block 1 3;1 3;1 3;
     1 2 2.1 3 1 2
sii ;-1;;2 m;
merge
stp .2
```

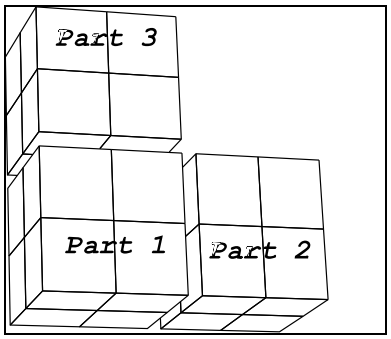


Figure 400 Before **stp**

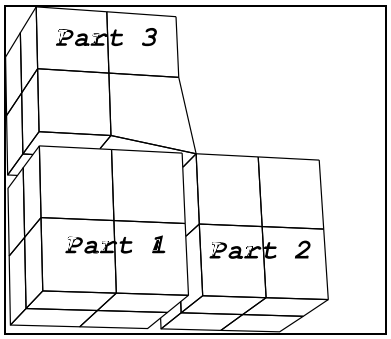


Figure 401 After **stp**

For other commands affecting how nodes are merged, see the "Merging Parts" section in the chapter "Global Commands".

fn tied node sets with failure

fn *region failure_strain*

Remarks

For each node in a region of 2-D shell elements, this command makes a duplicate node, tied to the original node with failure. Thus these nodes can break apart during the simulation, allowing the shell elements to break apart.

This command imposes the constraint called **tied node sets with failure**. It is used in DYNA3D and LSDYNA. Each failure node which is part of more than one 2D shell element will produce a tied node set with failure. A new node will be added for every 2D shell element that meets the original failure except for the first 2D shell element.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Fn generates more nodes at the time the output file is written. **True*Grid*®** will automatically correct for the renumbering in conditions which refer to node numbers, such as pressure surfaces and sliding interfaces.

Example

The input for this example is:

```
block 1 3;1 3;-1;0 1 0 1 1
b 1 1 1 1 2 1 dx 1 dy 1 dz 1;
b 2 1 1 2 2 1 dy 1;
lsys 1 rz 45 ;
lb 2 1 1 2 2 1 1 dx 1 ;
te 2 1 1 2 2 1 .1314
endpart
block 1 3;1 3;-1;1 2 0 1 1
fn 1 1 1 2 2 1 1.23456
lb 2 1 1 2 2 1 1 dy 1 ;
velocity .123 .234 .345
te 2 1 1 2 2 1 2.1314
endpart
block -1;1 3;1 3;2 0 1 1 2
fn 1 1 1 1 2 2 1.23456
endpart
merge
stp .001
dyna3d
write
```

Before the output file is written, there are 21 nodes. They are shown below in black numbers. Then additional coincident nodes are added and the element connectivity adjusted so that each shell element with failure nodes has it own independent nodes. The additional nodes are in red. The nodes within each the following sets will be tied together with a failure criterion: (7,22), (9,25), (10,26), (12,30), (13,31), (15,35), (16,36), (19,40), (20,41), (8,23,24), (11,27,28,29), (14,32,33,34), and (18,37,38,39).

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

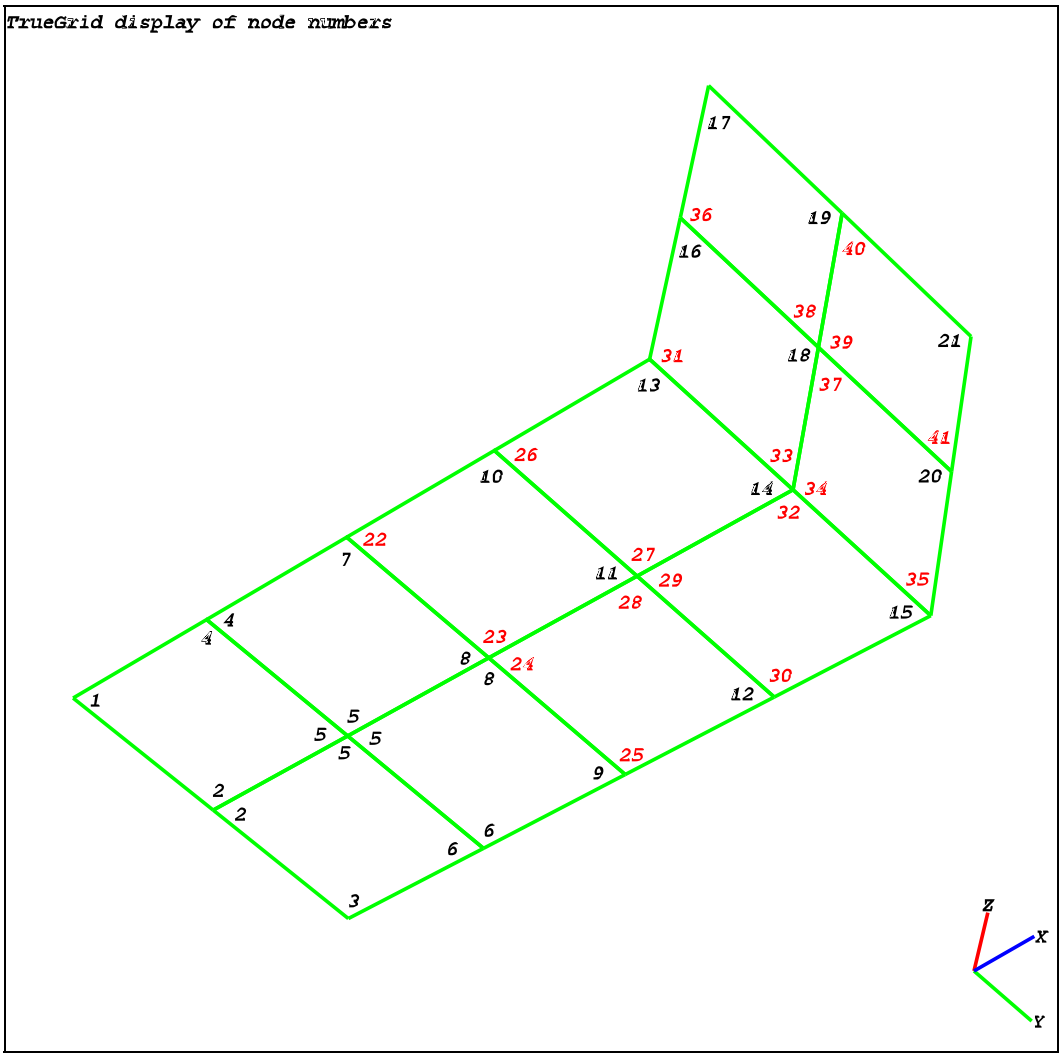


Figure 402 duplicate nodes automatically generated

fni tied node sets with failure

fni *progression failure_strain*

Remarks

For details, see the above description of **fn**.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

25. Output Commands

epb element print block

epb *region*

Remarks

This command is used with DYNA3D and LS-DYNA. It flags a region so that DYNA3D or LS-DYNA will print information on the region more frequently.

npb nodal print block

npb *region*

Remarks

This command is used with DYNA3D or LS-DYNA. It flags a region so that DYNA3D or LS-DYNA will print information on the region more frequently.

supblk select regions to be combined in the block structured output

supblk *region*

Remarks

Some fluids codes require multiple block data, sometimes referred to as grids, as opposed to unstructured element data. You must specify a fluids output option before creating the first part, if you want to write an output file for a fluids code requiring structured output. Each grid within a part becomes a part in the database. For example, if the third part is broken into two grids, that part becomes parts 3 and 4. You have control over how a block is decomposed into grids. In particular, any collection of blocks which can form a single logical block can be combined into one single grid. This can be important since it reduces the total number of interfaces and can reduce the run-time for the fluids simulation code.

If you choose nothing, then an algorithm will break the parts into grids for you. The algorithm first finds an undeleted block, and then groups blocks together with this block in order to form the largest possible single logical block. These blocks are removed from consideration, and the process is repeated. There

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

is no guarantee that this method will find the smallest number of logical blocks. Use the **supblk** command to specify a collection of blocks to be treated as a single logical block. Regions specified by the **supblk** cannot overlap.

The specified region must not contain any deleted region, or the command is ignored. Not every block need be part of some **supblk** command.

Example

```
block
 1 10 20;
  1 5 9 13;
    1 5 9 13;
   ... ; ... ; ... ;
supblk 1 1 2 3 4 3
c superblock applied t0
c region 1 1 2 3 4 3
c to create grid 1 and c
grids 2 and 3
```

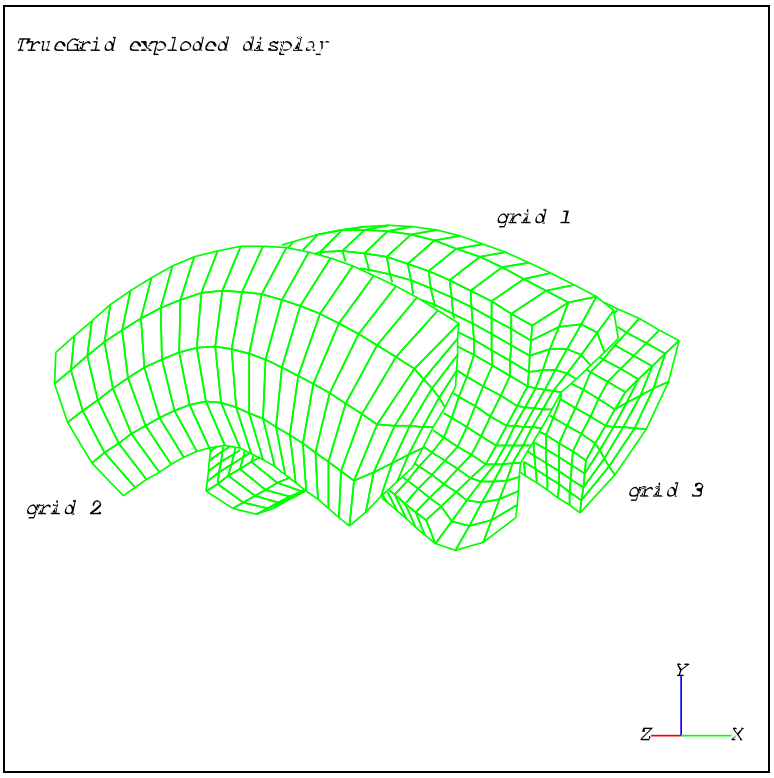


Figure 403 pipe with 3 grids

26. Sets

Named sets in the Part Phase are useful tools in defining boundary conditions, loads and materials and an alternative to named sets in the Merge Phase. The **delset** command deletes a set. The **eset** and **eseti** commands add/remove elements to/from a set of elements. The **fset** and **fseti** commands add/remove faces to/from a set of faces. The **nset** and **nseti** commands add/remove nodes to/from a set of nodes. The **nsetc**, **fsetc**, and **esets** commands attaches a comment to a node set, which is required for ALE3D. The same commands are used as a title for LSDYNA output. The **nsetinfo** command reports the node set names and number of nodes.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

The name of the set can be up to 8 alphanumeric characters long. Each name of the set must be unique. Since LSDYNA numbers its sets, one can use an integer as the name of the set.

In some of the set commands, the logical or Boolean set operators AND and OR are used to create new sets from existing sets. The AND operator between two sets means to take their intersection. This should not be confused with the common usage of and which might be interpreted to mean the addition of two sets. The OR operator does this function. The following is an easy way to remember these definitions.

An element is in set A "and" set B if it is in their intersection - the AND operator.

An element is in set A "or" set B if it is in their union - the OR operator.

delset delete a set

delset *type set_name*

where *type* can be

node

face

element

where *set_name* is the name of the set

Remarks

If a set was constructed but is no longer needed, then it is best to delete it with this command. This can be important if an output file is going to be written which automatically writes all sets. When deleted, the set will not be written to the output file and it will not be using memory.

eset add/remove elements to/from a set of elements

eset *region operator set_name*

where

set_name is the name of the element set

operator can be

=	for initial assignment
AND	for intersection with element set
OR	for union with the element set
-	for removal from the element set

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

The initial assignment creates an element set. If the element set with the same name already existed, then it is deleted and recreated. The intersect operator redefines an element set to be only those elements which are found to be both in the original set and among the selected elements. Selected elements can be added by using the union operator. This causes any selected elements to be included in a set, if it is not already in that set. The minus operator removes all elements in a set which are among the selected elements. An element set can have bricks, shells, and beams in one set. Some simulation codes may require that a set can have only one element type. Check with the specific simulation code. If an edge of the mesh is selected, then the shells or bricks with nodes along this edge will be selected for set inclusion. If a vertex is selected, than any beam, shell, or brick element with a node at that vertex will be included in the element set.

Example

The element set `eso` is created from the elements of the region `2 1 1 3 2 2`. The elements from regions `2 2 1 4 3 2` and `3 3 1 4 2 2` are added to the element set `eso`. The element set `eso` is displayed in the hide mode (**Figure 404**).

```
block 1 3 5 7 9; 1 2 3 4; 1 3 5;
      1 3 5 7 9; 1 2 3 4; 1 3 5;
eset 2 1 1 3 2 2 = eso
eset 2 2 1 4 3 2 or eso
eset 3 3 1 4 4 2 or eso
merge
labels elemset eso
```

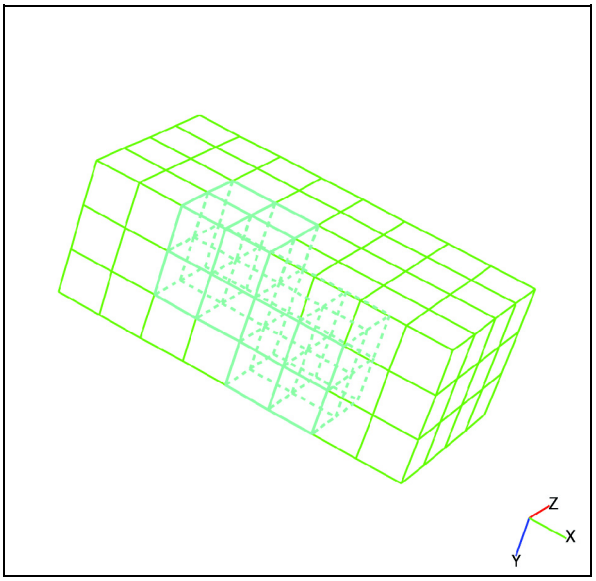


Figure 404 Element Set eso

eseti add/remove elements to/from a set of elements

eseti *progression operator set_name*

where

set_name is the name of the element set

operator can be

=	for initial assignment
AND	for intersection with element set
OR	for union with the element set
-	for removal from the element set

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

The initial assignment creates a face set. If the face set with the same name already existed, then it is deleted and recreated. The intersect operator redefines a face set to be only those faces which are found to be both in the original set and among the selected faces. Selected faces can be added by using the union operator. This causes any selected faces to be included in a set, if it is not already in that set. The minus operator removes all faces in a set which are among the selected faces.

fset add/remove faces to/from a set of faces

fset *region [side] operator set_name*

where

side	0 or 1optional argument choosing the element associated with the face
set_name	is the name of the face set
operator	can be
=	for initial assignment
AND	for intersection with face set
OR	for union with the face set
-	for removal from the face set

Remarks

The initial assignment creates a face set. If the face set with the same name already existed, then it is deleted and recreated. The intersect operator redefines a face set to be only those faces which are found to be both in the original set and among the selected faces. Selected faces can be added by using the union operator. This causes any selected faces to be included in a set, if it is not already in that set. The minus operator removes all faces in a set which are among the selected faces.

Faces in face sets are identified by an element number and an order number of a face in the element. Nodes in the face are ordered by the right hand rule (?). The vector in ? is always oriented outward from the element. The face is also identified by an ordered list of nodes forming the face. The method idenfifying the face depends on the output option.

The optional side argument applies only to faces of brick elements. It is ignored if the faces being selected are shell elements. Side can be 0 or 1 and it indicates which brick elements to use when selecting faces on the specified partition(s) in the mesh. If side=0, then the elements on the minimum index side are selected. If side=1, then the brick elements on the maximum index side are selected. This feature only affects those Finite Element output options where a face of a set is identified by an element number and a face ID. If a simulation code defines a face by these four nodes, then it is not affected by this new option. For example, suppose a two block, two element part is formed by

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
block 1 2 3;1 2;1 2;1 2 3;1 2;1 2;
```

and the face that is shared by these two elements is selected as a face set.

```
fset 2 1 1 2 2 2 0 = face_set_1
```

Then brick element number 1, face ID 3 would form the face set. If, instead

```
fset 2 1 1 2 2 2 1 = face_set_1
```

then brick element number 2, face ID 5 would form the face set.

Example

```
cylinder
 1 3 5;1 3 5 7 9;1 3 5 7 9; 2 3
4;-30 -15 0 15 30; 1 3 5 7 9;
fset 3 1 1 3 5 5 = stst1 merge
labels faceset stst1
```

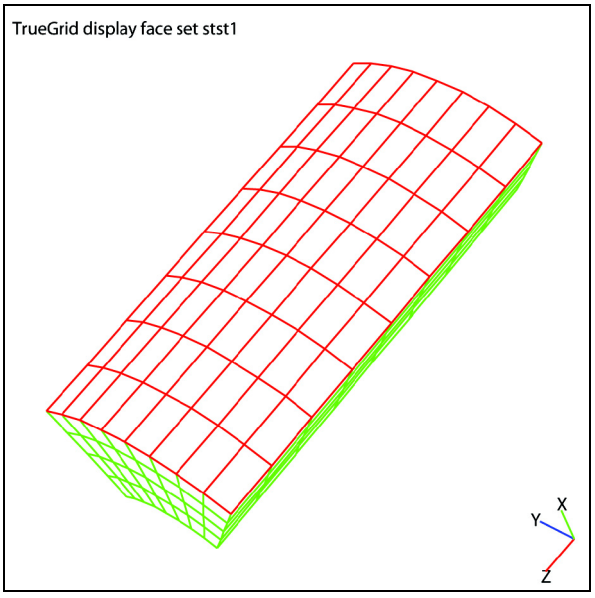


Figure 405 face set by **fset**

fseti add/remove faces to/from a set of faces

fseti *progression [side] operator set_name*

where

side	0 or 1optional argument choosing the element associated with the face	
set_name	is the name of the face set	
operator	can be	
	=	for initial assignment
	AND	for intersection with face set
	OR	for union with the face set

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

- for removal from the face set

Remarks

The initial assignment creates a face set. If the face set with the same name already existed, then it is deleted and recreated. The intersect operator redefines a face set to be only those faces which are found to be both in the original set and among the selected faces. Selected faces can be added by using the union operator. This causes any selected faces to be included in a set, if it is not already in that set. The minus operator removes all faces in a set which are among the selected faces.

Example

The face set **umvp** is initialized by the index progression `-3; ; ;` (upper face in 406). Then, it is extended by union with faces resulting from the index progression `; ;-5;` (front face in 406). The left bottom corner of the upper face represented by the index progression `-3;1 3;1 3;` is subtracted from the face set **umvp**.

```
cylinder 1 3 5;1 3 5 7 9;1 3 5 7 9;
2 3 4;-30 -15 0 15 30;1 3 5 7 9;
fseti -3; ; ;= umvp
fseti ; ;-5;or  umvp
fseti -3;1 3;1 3;-  umvp  merge
```

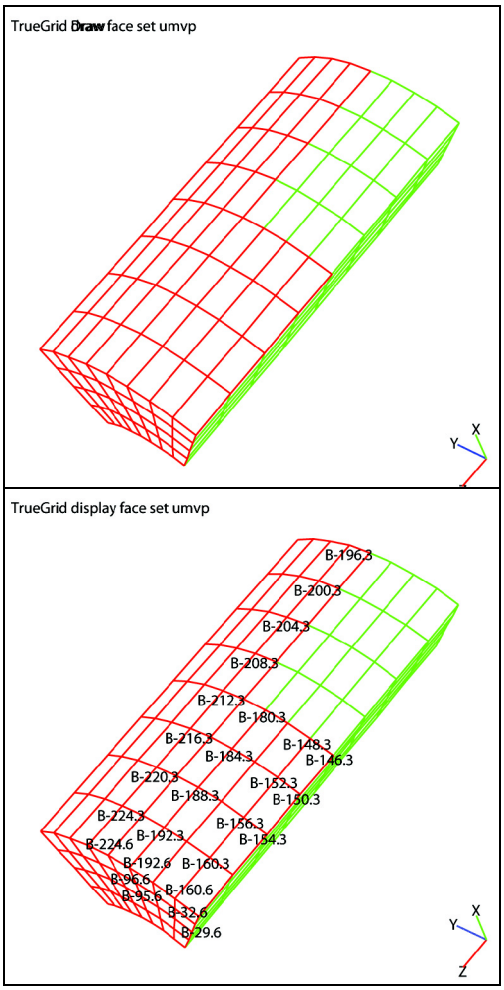


Figure 407 labeled face set umvp

nset add/remove nodes to/from a set of nodes

nset *region operator set_name*

where *set_name* is the name of the node set

where *operator* can be

=	for initial assignment
AND	for intersection with node set
OR	for union with the node set
+	to append the selected nodes to the node set
-	for removal from the node set

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

The initial assignment creates a node set. If the node set with the same name already existed, then it is deleted and recreated. The intersect operator redefines a node set to be only those nodes which are found to be both in the original set and among the selected nodes. Selected nodes can be added by using the union operator. This causes any selected nodes to be included in a set, if it is not already in that set. The add operator will always append selected nodes to a set. This is used to create ordered node sets where duplicate nodes are allowed. The minus operator removes all nodes in a set which are among the selected nodes. See the next command, **nseti**, for an example.

nseti add/remove nodes to/from a set of nodes

nseti *progression operator set_name*

where

set_name is the name of the node set

operator can be

=	for initial assignment
AND	for intersection with node set
OR	for union with the node set
+	to append the selected nodes to the node set
-	for removal from the node set

Remarks

The initial assignment creates a node set. If the node set with the same name already existed, then it is deleted and recreated. The intersect operator redefines a node set to be only those nodes which are found to be both in the original set and among the selected nodes. Selected nodes can be added by using the union operator. This causes any selected nodes to be included in a set, if it is not already in that set. The add operator will always append selected nodes to a set. This is used to create ordered node sets where duplicate nodes are allowed. The minus operator removes all nodes in a set which are among the selected nodes.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Example

The node set named **FC** is created (408). At first, an index progression `; ;-4;` is selected to form a node set name **FC**. Then the nodes from 4 inner and 4 outer edges are subtracted from the node set **FC**.

```
block 1 7 13 19;1 7 13 19;1 7 13 19;1
7 13 19;1 7 13 19;1 7 13 19;
dei 2 3; 2 3;;
nseti ; ;-4;= FC
nseti -1 0 -4; ;-4;- FC
nseti ;-1 0 -4;-4;- FC
nseti 2 3;-2 0 -3;-4;- FC
nseti -2 0 -3;2 3;-4;- FC
merge
```

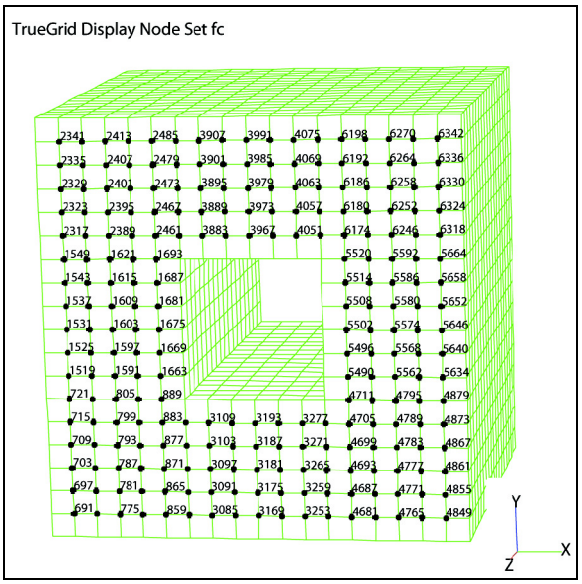


Figure 408 Node Set FC

Example

The node set named **pr** is created (?). At first, an index progression `;2 4 0 7 8; ;` is selected as a node set with name **pr**. Then index progression `;2 7;2 3;` is added to form a union with previously defined node set **pr**.

```
block -1;1 3 5 7 9 11 13 15 17;1 3
5 7 9 11;-1;1 3 5 7 9 11 13 15 17;1
3 5 7 9 11;
dei -1; 5 7; 3 4;
nseti ;2 4 0 7 8; ;= pr
nseti  ;2 7;2 3;or pr
merge
labels nodeset pr
```

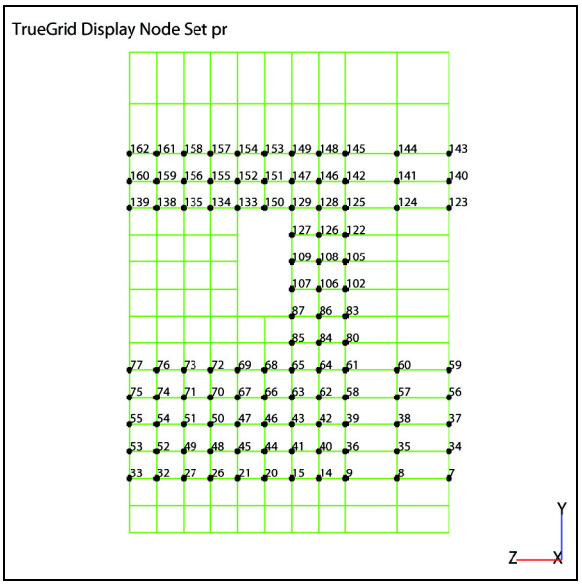


Figure 409 Node Set pr

nsetc attach a comment to a node set

nsetc *set_name text*

where *set_name* is the name of the node set

where *text* a text comment

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Remarks

It is necessary to specify a comment using **nsetc** for each node set to be written to ALE3D. These comments become titles for the LSDYNA output option.

fsetc face set comment

fsetc *set_name text*
where *set_name* is the name of the face set
where *text* a text comment

Remarks

It is necessary to specify a comment using **fsetc** for each node set to be written to ALE3D. These comments become titles for the LSDYNA output option.

esetc element set comment

esetc *set_name text*
where *set_name* is the name of the element set
where *text* a text comment

Remarks

It is necessary to specify a comment using **esetc** for each node set to be written to ALE3D. These comments become titles for the LSDYNA output option.

nsetinfo report the node set names and number of nodes

nsetinfo (no arguments)

27. Material Commands

Every material is identified with a number. Use the automatic parameter %nextmat for the next available material number. Material properties are defined by various commands associated with an output option. Refer to the various output manuals for further information.

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

mate part default material number for each region

mate *material_#*

where *material_#* is the referenced material number

Remarks

This command assigns material number for the whole part as a default. The material assignment can be overwritten by other commands (**mt**, **mti**) for any combination of the regions of the part.

Example See the **mti** command.

mt material number for a region

assigns a material number to a region, overriding any previous material specifications.

mt *region material_#*

Remarks

A material number need not correspond to a defined material model. To set up a correspondence between a material number and a material model, you must first select an output option, and then use one of the material definition commands to specify a material model and associate it with a material number (a positive integer). Although you may use a material number before associating it with a material model, you cannot specify a material model until after choosing an output option.

Use the global **mate** command to set the global default material number. Use the local **mate** command to set the default material number for an entire part. This overrides the global material number. Another related material command is **mtv**.

The specified material number applies to all 2D shell and 3D solid elements within the region.

You can selectively view different materials within a single part during the Merge Phase. Use the **m**, **am**, **rm**, **dam**, and **dms** commands.

mti assign material number

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

mti *progression material_number*

where

progression	index progression the material is assigned to
material_number	number of the assigned material

Remarks See the **mt** command.

Example

The mesh is defined by the **block** command. Material 3 is assigned by the **mate** command to the whole part. The **mti** command specifies material for 3 regions (413, 414, 415) gradually. 411 shows materials displayed in various colors in the **Fill Mode**. The simplified command file follows:

```
c Definition of the structured block part (shells).
block 1 5 9 13 21 25;1 -3 5;-1 5 9 -13;
          0 1 2 3 4 5;-.6 0 .6;-1 -.3 .3 1;
dei 2 3 0 4 5; -2; 2 3;  c Deletion of 2 regions
c Assignment of the default material of the part
c (material number 3).
mate 3
c Assignment of the material number 4 to the region  (;;-1;).
mti  ;; -1; 4
c Assignment of the material number 5 to the region  (;;-4;).
mti  ;; -4; 5
c Assignment of the material number 6 to the region  (;;2 3;)
mti  ;; 2 3; 6
merge
dam disp       c Display of all materials - Hide mode.
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

```
dam tvv          c Display of all materials - Fill mode.
```

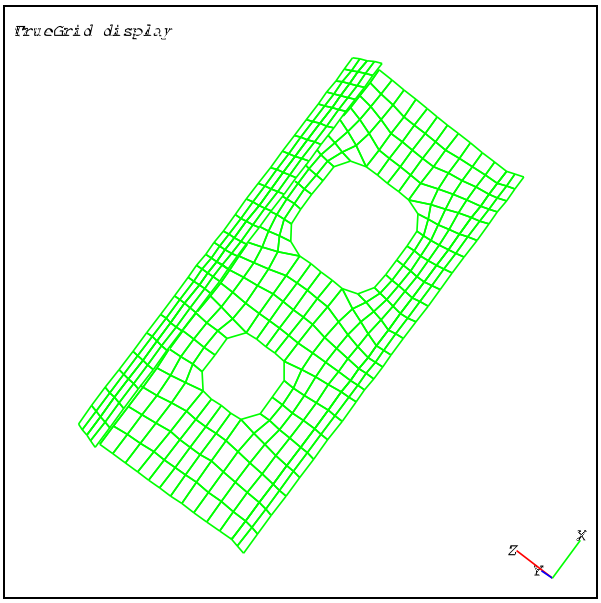


Figure 410 All Materials - Hide Mode

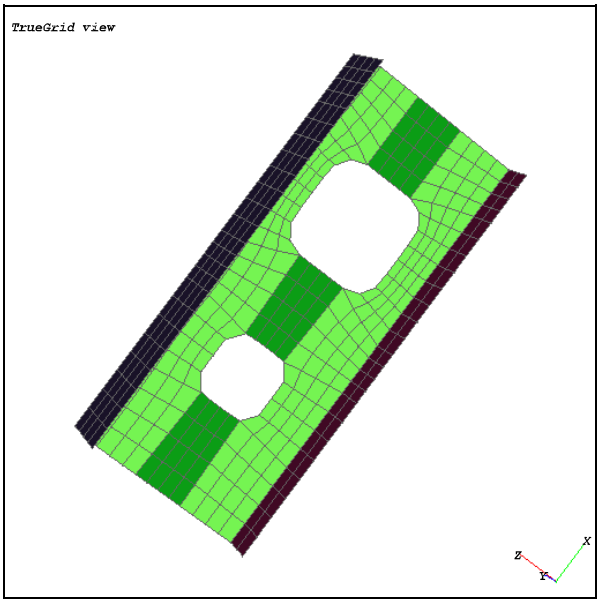


Figure 411 All Materials - Fill Mode

```
dm 3             c Display of material number 3.
dm 4             c Display of material number 4.
dm 5             c Display of material number 5.
dm 6             c Display of material number 6.
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

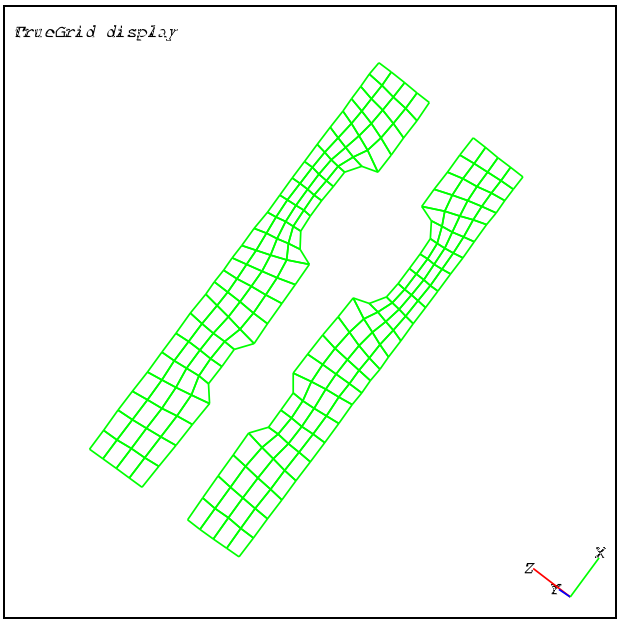


Figure 412 Material 3

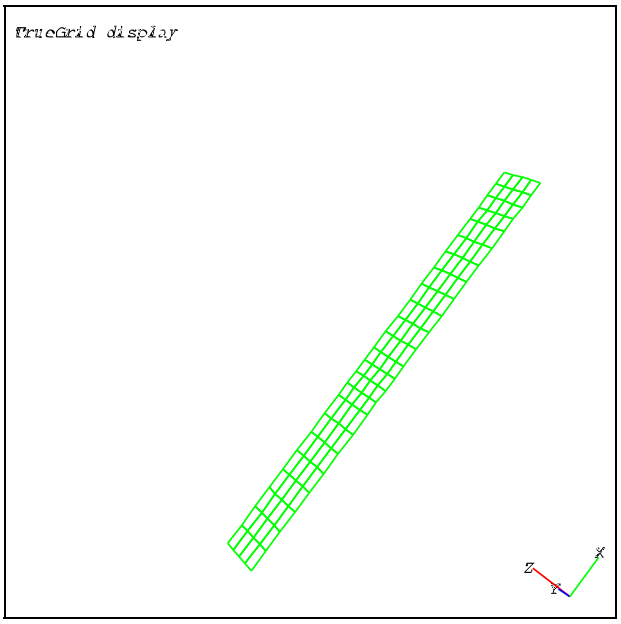


Figure 413 Material 4

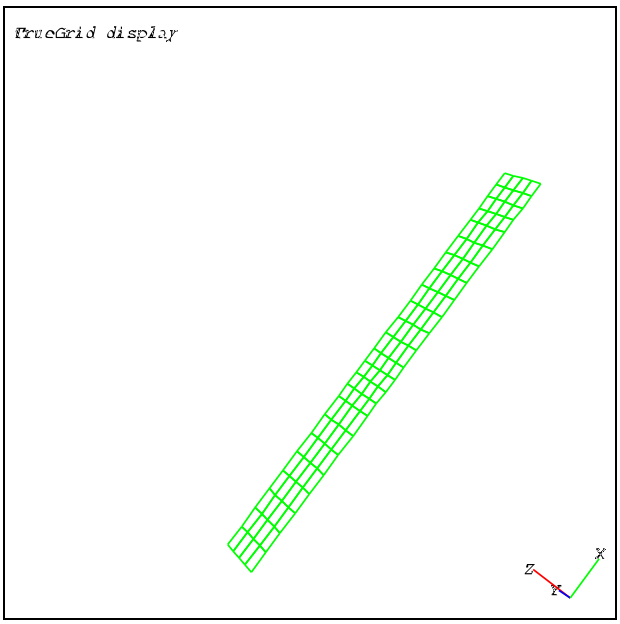


Figure 414 Material 5

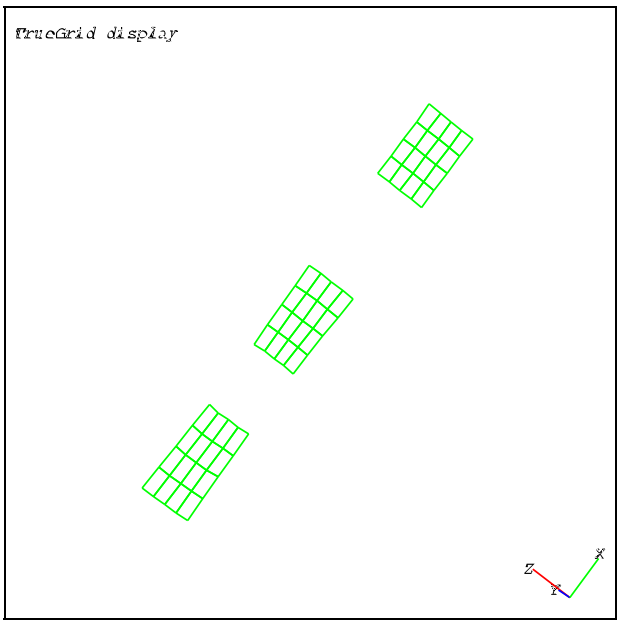


Figure 415 Material 6

Example

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Material number 2 is assigned to the index progressions of the mesh. It has a special meaning for the **AUTODYN** output option. The assigned regions are blanked in this way gradually (416 and 417). 418 represents the finished mesh of the fluid between 2 pipes. The simplified command file follows:

```
autodyn  c output option
c Definition of the structured block mesh
block 1 10 20;1 5 9 13;1 5 9 13; ... ; ... ; ... ;
mti ;1 2 0 3 4;1 2 0 3 4; 2
  c Assignment of material 2 to index progression
  c ;1 2 0 3 4;1 2 0 3 4; -> deletion of corners of the
  c butterfly mesh
mti ; 2 3; 2 3; 2
 c Assignment of material 2 to index progression
 c    ; 2 3; 2 3; 2 -> deletion of the core of the tube
merge
```

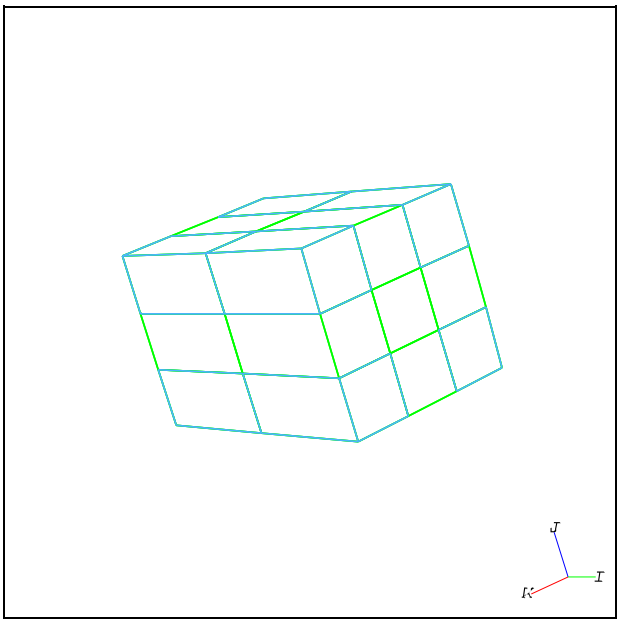


Figure 416 computational window

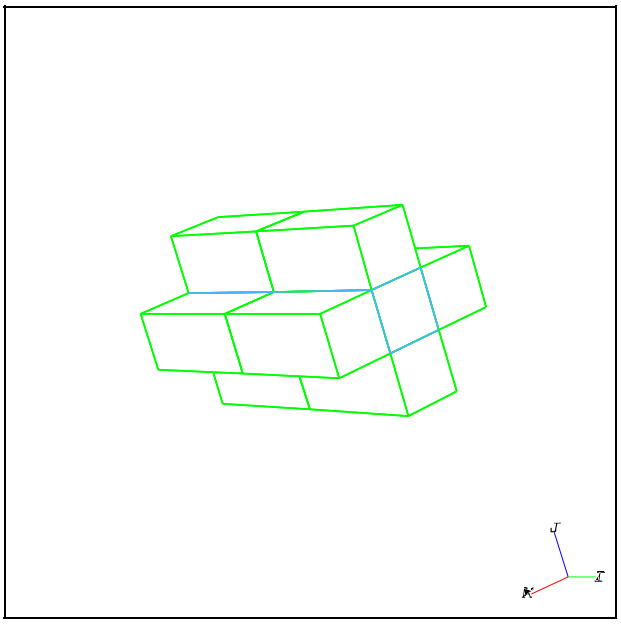


Figure 417 computational window

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

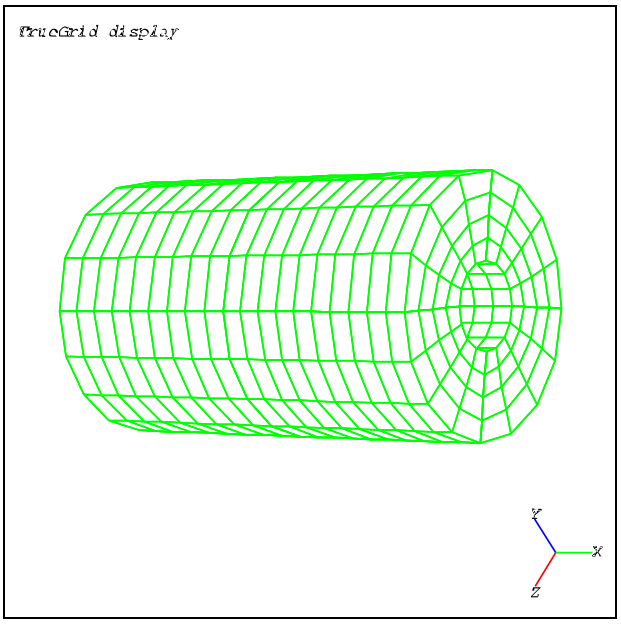


Figure 418 mesh of the fluid between 2 pipes

mtv material number assigned to a specified volume

mtv *i1 j1 k1 i2 j2 k2 volume_# mode default_material_# material_pairs*

where:

i1 j1 k1 i2 j2 k2 region

volume_# number of the volume definition used (defined using the **vd** command)

mode

where *mode* can be

2 for center of element in the volume

3 for one node in the volume

4 for half of the nodes in the volume

5 for all of the nodes in the volume

default_material_# the default material number is the number materials are changed to if the original material number is not found in the list of pairs

material_pairs each pair of material numbers consists of an original material number found in the volume followed by its new number.

Remarks

The **mtv** command references a volume to select elements in the volume. The elements of the selected region can be either bricks or shells. There are several types of volumes. They are: a sphere, an

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ellipsoid, an infinite cylinder, a finite cylinder, a rotated 2D curve, and a surface with thickness.

It is possible to assign a material of zero to a region or part in the part phase and then apply the **mtv** to change the material from zero to another material within that region.

These features also apply to **SPH** smooth particle elements (see **SPARTICLE**) for **LSDYNA**.

Example

The mesh is created by the **block** command (419 and 420). A 2D spline curve is defined by the **ld** command (421). A volume is created by the **vd** command (422). Material 2 is assigned to the elements within the volume by the **mtv** command (423 and 424). The command file follows:

```
c Structured block mesh definition.
block 1 21;1 21;1 21;0 2; 0 2; 0 2;
c Default material is assigned to the part.
mate 1;
c Definition of the 2D curve number 1.
ld 1 csp2 00 0 0 1 .5 1.5 1 1 1.5 0 2; ;   c Type of curve is 2D
 c spline with the natural end derivatives (csp2 00).
 c The spline is defined by the pairs of coordinates (x,z)
 c of the control points. The coordinates of the control points
 c are: (0,0),(1,.5),(1.5,1),(1,1.5), and (0,2).
lv                              c Display 2D curves.
c Definition of the volume number 1 for the assignment
c of the material
vd 1 cr 0 0 0 0 0 1 1     c Volume is created by rotation
 c of the 2D curve around axis given by the local coordinate
 c origin (0,0,0) and the vector parallel to the axis
 c of rotation (0,0,1). The number of the 2D curve is 1.
c Assignment of the material to the volume.
mtv 1 1 1 2 2 2 1 2 2 ; c The material is assigned to the region
 c 1 1 1 2 2 2. The volume definition number is 1. Mode of the
 c selection of the elements is Element Center Within Volume(2).
 c Material number 2 is assigned to the elements within the
 c volume.
merge
dm 1          c Material 1 is displayed in the Merge Phase.
dm 2          c Material 2 is displayed in the Merge Phase.
```

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

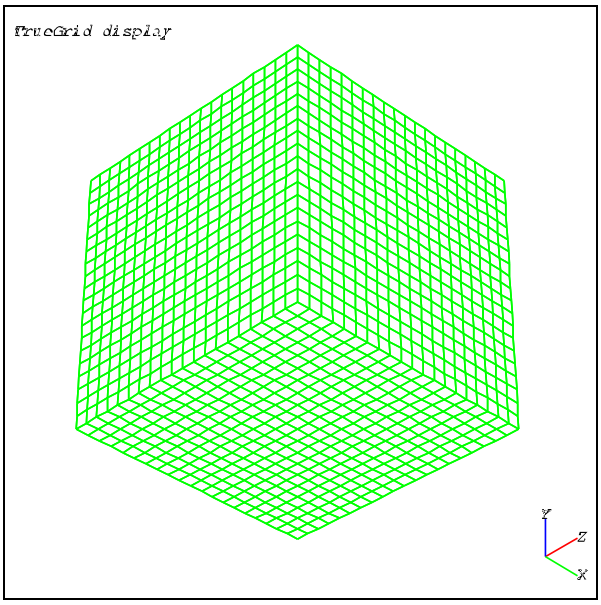


Figure 419 Physical Mesh

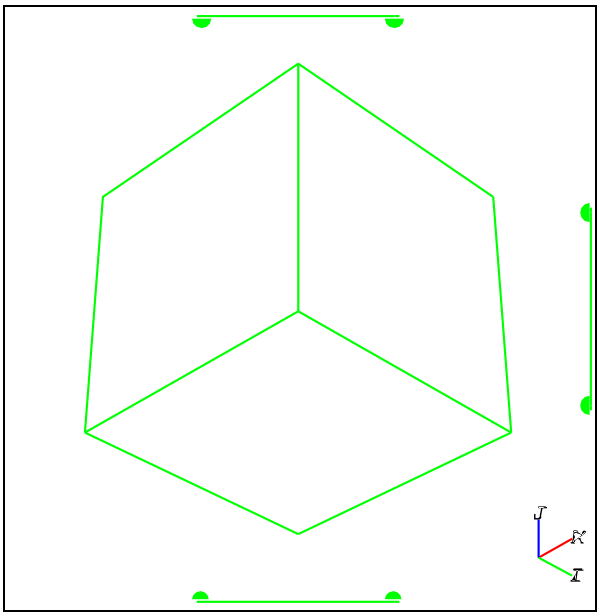


Figure 420 Computational Mesh

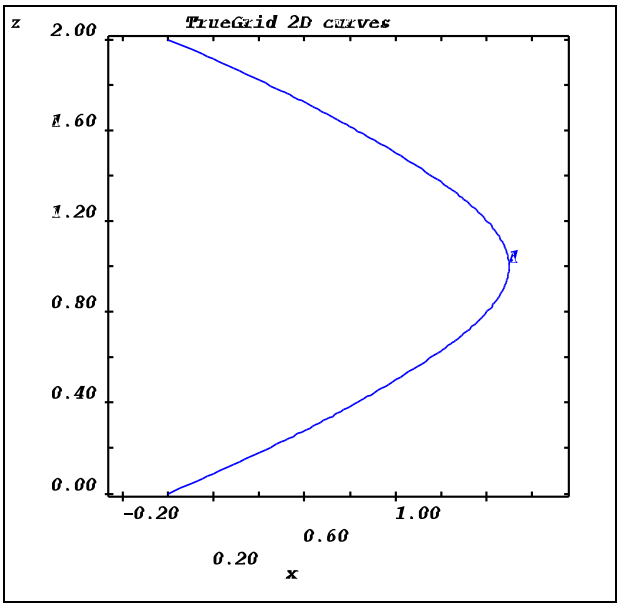


Figure 421 2D Spline Curve

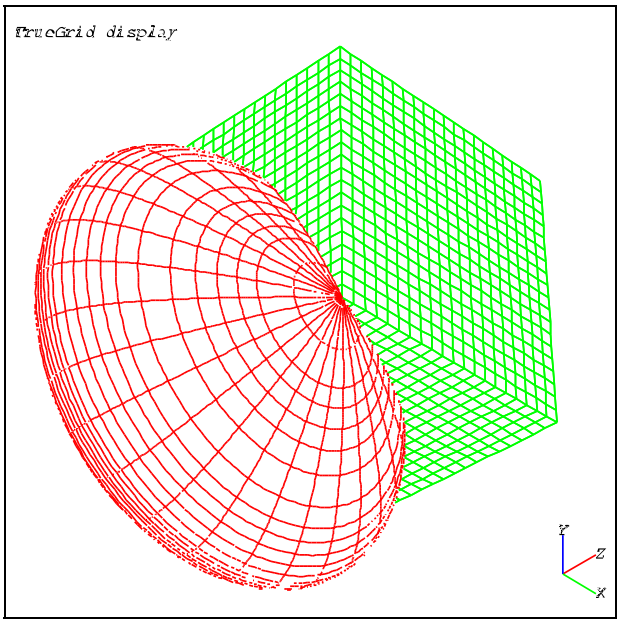


Figure 422 Surface corresponding to the Volume

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

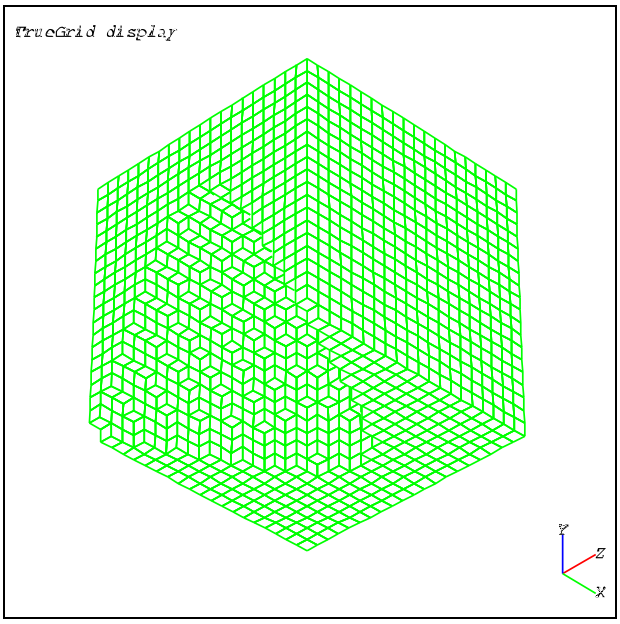


Figure 423 Elements with Material 1

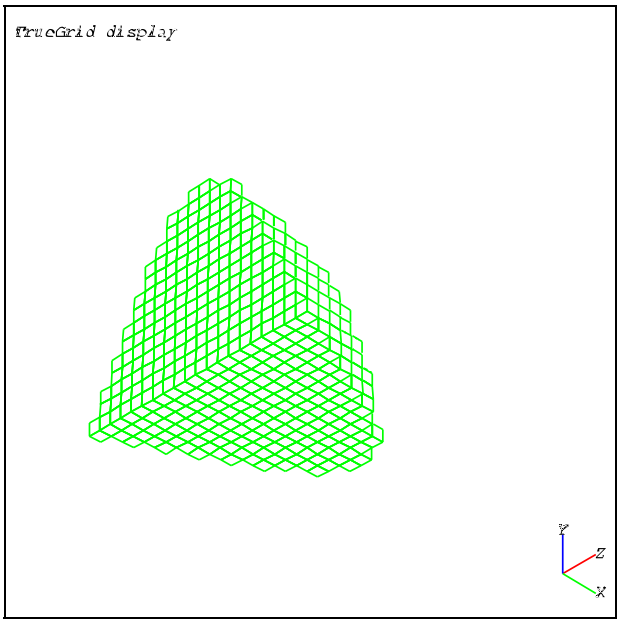


Figure 424 Elements with Material 2

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

por to specify the region with porosity for REFLEQS

por *region type beta option*

where type can be

v	for porosity applied to volumes
vw	for porosity applied to volumes with walls
vt	for porosity applied to volumes with walls and temperature
w	for porosity at west faces of cells
s	for porosity at south faces of cells
l	for porosity at low faces of the cells
vc	for porosity of a volume core (same as V,W,S,&L combined) followed by west, south, and low porosities

beta is the porosity between 0 and 1 including 0
option is the temperature only if type is **vt**

pori to specify the region with porosity for REFLEQS

por *progression type beta option*

where type can be

v	for porosity applied to volumes
vw	for porosity applied to volumes with walls
vt	for porosity applied to volumes with walls and temperature
w	for porosity at west faces of cells
s	for porosity at south faces of cells
l	for porosity at low faces of the cells
vc	for porosity of a volume core (same as V,W,S,&L combined) followed by west, south, and low porosities

beta is the porosity between 0 and 1 including 0
option is the temperature only if type is **vt**

sc to define the ale smoothing constraints for LS-DYNA3D

sc *region direction*

where direction can be

i
j
k

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

IV. Index

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

.tgauth. 26
;. 74, 285
equations. 285
list. 33, 64
para. 170
(
expressions. 170, 284
)
expressions. 170, 284
{
Comments. 64
{...}. iv
}
Comments. 64
$. 285
comment. 64
Comments. 64
equations. 285
+
equations. 284
expressions. 170
node set. 467
-
element set. 463
equations. 284
expressions. 170
face set. 465
node set. 467
*
equations. 284
expressions. 170
**
equations. 284
expressions. 170
/
equations. 284
expressions. 170
^
equations. 284
<progression> notation. 55
<region> notation. 55
<vertex> notation. 55
=
element set. 463
equations. 283
face set. 465
node set. 467
%
parameters. 170
&. 285
equations. 285
esm. 232
expressions. 64
relax. 244
relax example. 233
unifm. 261
0. 35
2D Curves
display. 112
window. 70
3D Curves. 37, 194
attach. 214
attaching. 154
attaching to. 152
beams. 425
Coedge. 112
composite. 112
constraint. 217, 225
F5. 145
Initialization. 224
interactive. 173
interpolation. 224
labeled points. 111
labels. 111
Lp3. . . . . 112, 150
modify intersection. 143
modify polygonal. 143
modify spline. 143
numbers. 111
point numbering. 111
retrieve. 185
Spline. 112, 150
Twsurf. 112, 150
undo. 166

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

72REL3. iv
Aad. 75
ABAQSTEP. iii
constraints. 346
ABAQUS. . . . . iii, 326
load set number. 346
Abb. 393
Abbs. 393
ABDLOAD
ABAQSTEP. iv
Abort
undo. 166, 293
Abs
Expressions. 284
ACC. . . . . iii, 311, 314
Accc. 313
Accci. 313
Acceleration. 311
acc. 311
accc, cylindrical. 313
accci, cylindrical. 313
acci. 312
accs, spherical. 315
accsi, spherical. 315
frb. 306
vacc. 321
vaccc, cylindrical. 322
vaccci, cylindrical. 323
vacci. 322
vaccs, spherical. 324
vaccsi, spherical. 324
Accept button. 176
Acci. 312
Accs. 315
Accsi. 315
Acos
Expressions. 284
Actcmd. 166, 289, 292
decmd. 292
undo. 293
Activate. 288
activation of commands. 166
and update. 203
Active
in history table. 289
Ad. 75
Add
button. 138
elements. 199
Add
region. 195
Add button. 130
Address. 24
After button
Point list. 175
AJEL. iv
Algebraic Methods. . . 42, 203, 247, 254, 278
Algorithm
of interpolation. 237
of selection. 49
ALLTETS. vi
Am
Mt. 471
analysis options. 27
And
element set. 463
face set. 465
node set. 467
Angle. 92, 106, 146
Anisotropic
material. 422
Annotations
aad. 75
ad. 75
daad. 76
dad. 76
dads. 77
pad. 78
raad. 80
rad. 80
ANSYS
boundary conditions. 367, 368
cvt. 367
APAINFO. iv

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Arg. 138, 294
Argi. 138, 295
arquah
rivet hole. 412, 415
Arri. 326
Arrow
ad. 75
Arrow button in text in window. 74
Arrow keys. 73
As. 30, 278
cur. 224
edge projection. 269
esm. 232
Lin. 235
relax. 243
Tf. 248
Tme. 253
Asin
Expressions. 284
aspect
rivet hole. 412
Aspect ratio. 445
Mesh quality. 447
Assemble. 27
Assign
coordinates. 206, 213
Atan
Expressions. 284
Atan2
Expressions. 284
Attach. 70
button. 205, 273
edge. 214
labeled point. 207
project. 217
Attach button. 112, 125, 152, 164
Attaching. 27, 120
3D curve. 154
block boundary. 156
in Z-buffer. 157
parts. 156
region. 152
surface edge. 155
to a labeled object. 155
to a lassoed object. 156
to a node. 159
to a point. 158
to an edge. 227
z-coordinate. 154
Authorization. 25
file. 26
automatic
rivet hole. 410
Automatic drawing algorithm. 83
Automatic Parameters. iv
list. iv
splines. iv
B. . . . . iii, 346
boundary constraint. 346, 347
example. 67, 459
lb. 357
lbi. 357
Backplane
draw. 77
poor. 79
z-buffer. 123
Backspace
in dialogue box. 171
Basic Concepts 29
Batch. 56
intro. 22
Batch execution. 26
Batch file. 58, 166
BB. 138, 194, 385, 451
attaching. 152, 153
attaching to. 156
button. 113, 137
display numbers. 300
esm. 232
hierarchy. 194, 195, 203, 204
intra-part. 262, 389
intro. 22
pb. 206, 207
relax. 244

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

smoothing. 230
spherical projection. 271
trbb. 403
Bbinfo. 391
Bbint. 394
beam
quadratic. iv
Beams. 22
button. 113
create. . 425, 429, 432, 434, 437, 440
create, sets. 133
cross sections. 425
embeded. 425
labels. 111
merge. 444
Beams Button. 130
Bf. 365
Bfi. 365
Bi. 347
constraints. 346
lb. 357
lbi. 357
Bi-linear Interpolation. 237
Bind. 425
Blend3. 174
Blend4. 174
Blending the shapes. 40
Block. . . . 33, 34, 37, 43, 44, 50, 94, 97, 123
attaching. 152
beams. 425
boundary list. 291
de. 195
deleting. 195
endpart. 450
example. 66
geometric selection. 97
hierarchy. 194, 203
initial mesh. 202
insprt. 196
intro. 22, 64
Mseq. 199
part. 30, 44
part and Lin. 235
selection. 95, 104
structure. 94, 123
tghist file. 58
undo. 166, 293
update. 202
Block Boundary
attaching to. 152, 156
intro. 22
pick node. 123
Blude. 33
endpart. 450
insprt. 196
intro. 64
mseq. 199
part. 30
undo. 166
Bm
intro. 22
npm. 381
part. 425
Bold
syntax. 55
Both. 108
Both button. 97, 108
Boundaries. 38, 230
concave. 231
convex. 231
curvature. 256
interpolation. 230
orthogonality. 258
Boundary conditions
b. 346
bi. 347
convection. 366, 367
convection thermal load. . . . 367, 368
current. 371
fluid flow. 371
flux. 368, 369
heat flow. 371
interpolation. 275
local. 356, 357

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

magnetic flux. 371
temperature. 369, 370
Boundary layer
tme. 255
Boundary radiation. 374
Bounding face. 40
Bptol. 456
npm. 381
Brick
material orientation. 418
Bricks
face set. 133
labels. 111
Bricks button. 113, 130
BSD. . . . . iv, 425
dialogue box. 168
Ibm. 428
Bulc
orpt. 201
Bulk fluid
bf. 365
bfi. 365
Butterfly topology. 193, 214
Button
attach. 273
BB. 137
both. 97, 108
cent. 108
comp. 108
Curve. 137
delete. 101
draw. 97, 108
Edge. 137
Exec/Quit 102
fill. 105
frame. 109, 110
hide. 105
Label. 137
labels. 113, 137
move. 109, 110
phys. 108
region. 124, 137
Remove. 137
rest. 108
rotate. 109
Shoe All. 137
Shoe None. 137
Shoe Only. 137
surf edge. 137
Surface. 137
wire. 105
zoom. 109, 111
Bv. 311
Bvi. 311
CAD. 62
Caption. 75
ad. 75
Cartesian Coordinates. 143
Cent button. 108
Center. 86, 93
Center of rotation. 90
Cfc. 348
Cfci. 349
Cfx
flowint. 396
Check commands. 447
Check Sum. 25
chz. 394
chzi. 395
Circle
ad. 75
Cj
jt. 351
Clear All button
Edge list. 174
Clear button. 130
Click-and-drag. 94, 95, 102, 124
Close Curve button. 191
Clrghl. 300
Cn2p (Sd option). 266
Cn2p (Sfi option). 269
CO
DEM. v
dx. 347

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

dy. 347
dz. 347
facial properties. vi
frb. 306, 307
MPCE. vii
or. 422, 436, 440
rx. 347
ry. 347
rz. 347
si. 399
thickness. 424, 425
Coedg. 189
button. 174
interactive. 173
Coedge. 112
example. 216
intro. 23
cohesion. 394, 395
Color
graphics. 106
highlighting. 96, 98
in dialogue box. 168, 171, 172
mesh. 95, 96, 98, 101
setting. 83
Column. 36
Command
activation and update. 203
file. 33, 58
Hierarchy. . . . 40, 202, 230, 287, 288
in menus. 72
line. 57
menu. 73
order of execution. 203, 230
Sequence. 290
syntax. 73
Command file. 57
intro. 22
Command Hierarchy. 194, 266
equations. 283
History. 290
initialization. 203
update. 202
Commands
issuing in text window. 74
Comment
equations. 285
ESETC. iv
FSETC. iv
NSETC. iv
Common node. 41
Comp. 108
Comp button. 108
Complex surfaces 38
Composite
boundary. 174
boundary curve. 216
curve. 174
surface. 39, 174, 189, 216, 222
Computational mesh. 29, 43
Computational window. 70, 81, 86, 94
Concave boundary. 233, 244
esm. 231
relax. 233, 244
tme. 254
Condition. 27
boundary. 346
si. 399
tvv. 85
Conditions
example. 68
Cone. 273
project. 266, 269
Cone (Sd option). 273
Cone (Sf option). 266
Cone (Sfi option). 269
Configuation. 172
Confirm
selection. 174
Constraint. 27
3D Curves. 217
boundary. 346, 347
boundary, local. 356, 357
movement. 143
projection. 160

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

surface. 153
surfaces.. 265
to a curve. 194
to a part.. 194
to a surface. 194
Constraint Equation. iv
MPCE.. vii
constraints.. . . . . 27, 40
Contact XYZ.. 24
Control. 62
endpart. 450
intro. 64
phase.. 62
points. 29, 246
Control Key Functions. 95
A.. . . . . 95, 96, 172
B.. . . . . 168, 172
Control Q. 172
Control U. 173
Control V. 173
Control X. 173
Control Z. 172
D.. . . . . 96, 173
E.. . . . . 171, 173
F.. . . . . 168, 173
P.. . . . . 96, 97, 173
Q.. . . . . 73, 173
V.. 168
X.. 171
Z.. . . . . 167, 173
Control phase. 64
Control Points.. 150
3D curves. 173
Convection
boundary conditions. 366, 367
cv. 366
cvi.. 366
cvt.. 367
cvti. 368
vcv. 366
vcvi.. 367
Convection thermal load
boundary conditions. 367, 368
Convergence
esm. 232
projection. 152
relax. 244
tme. 253
unifm.. 261
Convex boundary. 240, 244, 262
esm. 231
relax. 262
tme. 254
Coordinate System. vi
equations.. 282
global vs. picture. 85
Interpolation. 235
Local display. 422
pick points. 122
Triad display. 84
coordinates. 125, 143
assign to vertices. 203
by Z-buffer. 122
curve.. 122
print. 112, 172
scrolling. 144
surface. 122
surface edge. 122
Cooref.. . . . . 207, 208
Copying in text window
middle mouse. 74
Cos
Expressions. 284
Cosh
Expressions. 285
countersink
rivet hole. 410
Courier font. 55
Cp (Sd option). 273
Cp (Sf option).. 267
Cp (Sfi option). 270
Cr (Sf option). 267
Cr (Sfi option). 270
Cross Hairs.. 148

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Cross section
element. 418
Crule3d. 174
Crx. 273
Crx (Sf option). 267
Crx (Sfi option). 270
Cry (Sd option). 273
Cry (Sf option). 267
Cry (Sfi option). 270
Crz. 273
Crz (Sf option). 267
Crz (Sfi option). 270
Csca
thickness. 425
Tr. 209
Tri. 211
Csf. 332
Csp3 (Curd option). 173
Cubic spline
curve. 246
Cur. 30, 194, 224, 389, 407
attaching. 152, 153
cure. 226
curf. 225
curs. 226
edge. 227
hierarchy. 194, 203
Curd. 37, 138, 150, 451
contour example. 215
csp3. 173
csp3 example. 214
example. 66
interactive. 173
intro. 23
lp3. 173
Sdedge. 155, 174, 189
Se. 174, 189
se example. 216
twsurf. 173
undo. 293
Cure. 30, 194
attaching. 152-154
example. 215
hierarchy. 194, 203
initialize. 225
Curf. 30, 194, 225
attaching. 152, 153
hierarchy. 194, 203
usage. 221
Current
boundary conditions. 371
Curs. 30, 194, 226
attaching. 152, 153
example. 216
hierarchy. 194, 203
intro. 23
Curs (Curd option). 227
Curser
blue. 171
in dialogue box. 171
red. 171
Curser in dialogue box. 112
Cursor in text window. 74
Curtyp
attaching. 154
Curvature. 39
3D curves. 223
Curve
3d. 37
button. 113, 137
display numbers. 300
importing. 37
list. 291
rotated about axis. 273
Curve Button. 138
Curve Point button. 113
Curve rotated
project. 267, 270
Cur 37
Cuurd
intro. 23
Cv. 366
oprt. 201
Cvi. 366

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

oprt. 201
CVT. . . . . iii, 367
oprt. 201
Cvti. 368
oprt. 201
Cy (Sd option). 273
Cy (Sf option). 266
Cy (Sfi option). 269
cycorsy. 448
initialization. 204
Cylinder. 33, 37, 44, 144, 273
Beams. 425
endpart. 450
equations. 282
example. 207, 282
frame of reference. 448
Hierarchy. 194, 203
initialization. 204
insprt. 196
intro. 22, 64
Mseq. 199
orpt. 201
part. 30, 44, 230, 439
part and Lin. 235
pick points. 122
project. 266, 269
tghist file. 58
undo. 166, 293
Cylindrical Coordinate System
1d. 44
Cylindrical Coordinates. 143
D. 86, 88, 110, 111
both. 108
Daad. 76
Dabb. 138, 393
Dacd. 138
example. 116
Dad. 76
Dads. 77
Dailogue box. 70
Dam. 138
Mt. 471
Dap. 138, 159
example. 117
Darg. 138, 296
Darged. 138, 297
Das. 30, 278
Cur. 224
edge projection. 269
esm. 232
example. 216, 254
Lin. 235
relax. 243
Tf. 248
Tme. 253
Dasd. 138
example. 114
Data
files. 26
Data files. 26
date. iii
Dbb. 138, 392
Dbbs. 138, 393
Dcd. 138
Dcds. 138
De. 30, 33, 41, 151, 194, 195
example. 66
Deactivate. 43, 288
deactivated
tghist. 60
Deactivated command. 166
in history table. 289
Debug mesh. . . . 70, 102, 123, 166, 287, 288
Decmd. 166, 289, 292
actcmd. 292
undo. 293
Degrees. 285
Dei. 30, 33, 101, 102, 151, 194, 195
Delete
button. 101
character. 173
index progression. 151
progression. 195
region. 151, 195, 244

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

region & relax. 230
region and tme. 253
regions and unifm. 261
set. 463
text. 173
Delete button. 66, 151, 176
delset. 463
DEM. iv
DEMICLE. iv
Demonstration program. 24
demp. 418
dempi. 419
Derivatives
cubic spline. 181
Dgrp. 139
Dgrps. 139
Dial. 64, 70, 102, 167
Dialogue box. 36, 70, 105, 167
creating from menu. 72
F7 Key. 122
F9 Key. 122
history. 289
maximize. 168
mesh selection. 95
quitting. 73
verbose. 173
Directional projection. 270
Dirichlet boundary. 230
neu. 257
Dis. 316
Discontinuous. 38
Discrete Element. iv
discrete element spheres. 418
Discrete Elements
Graphics. v
Disi. 317
Disp. 77
draw. 77
poor. 79
resolution. 92
tvv. 85
Displacement. 301, 326
fd. 301
fdc. 302
fdci. 303
fdi. 301
fds. 304
fdsi. 304
frb. 306
frbi. 306
Display. 57, 61, 77
block boundary. 137
curve. 137
in X Window System. 61
list. 137
Option. 61
progression. 137
region. 137
surface. 137
Display Item
history. 290
Display List. 120
display ndd. 281
Dist. 331
Distributed Loads
DSLOAD. . . . . iv, vii
Distribution, nodes. 275
Dlv. 139
Dlvs. 139
Dm. 138
Dms. 138
Mt. 471
dndd. 281
nds. 279
Dom. 42, 283
example. 283
Pramp. 345
X=. 283
Dotted line
ad. 75
Double Precision. 25
Dp. 138
Dpic. 110, 111
Dps. 138

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Draw. 77
button. 97, 102, 106
disp. 77
poor. 79
sdint. 81
tvv. 85
Draw button. 66, 108
disp. 77
draw. 77
poor. 79
tvv. 85
Drawing algorithm
automatic. 83
Drs. 30, 277
Cur. 224
das. 279
edge projection. 269
esm. 232
relax. 243
Tf. 248
Tme. 253
Dsd. 138
Dsds. 138
DSLOAD. iv
ABAQUS. vii
dv
cycorsy. 448
DYNA3D. . . . . iv, 326
Epb. 461
Npb. 461
tepro. 377
DYNAMATS. iv
example. 66
Dynamic Movement of the Picture. 109
Dynaopts
example. 65
Edge. 30, 32, 40, 94, 123, 194, 227
attach. 214
attaching. 152, 153, 155
button. 137
hierarchy. 194, 203
Insprt. 227
intro. 46
list. 112, 174, 291
movement. 143
nodal distribution. 275
node. 231
projection. 40
selection. 95, 101, 103
edge numbers
display. 300
labels. 111
edgefile. 63
Edit
dialogue box. 171
Efl. 379
Efli. 380
Electric flux
efl. 379
efli. 380
Element
closest. iv
cross section. 418
labels. 111
print block, epb. 461
Element set. 129
comment. 470
delete. 463
modify. 130, 463
elements
add. 199
Ellipse. 273
Ellipsoid
project. 266, 269
Elliptic method 42
Elm
mea. 447
measure. 445
Elmoff
mea. 447
Email. 24, 28
End. 62, 72
Ending Your TrueGrid® Session. 62
Endpart. 449

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

example. 67
intro. 64
updates initial mesh. 202
Enter
in dialogue box. 171
Enter commands. 70
Enter Key. 74
Environment varable
TGHOME. 25
Environment Window. 70, 93, 94, 105
attach mesh. 152
display list. 137
dynamic moving. 109
history. 166
labels panel. 111
move points. 143
new picture. 108
picking objects. 120
picture selection. 105
project mesh. 160
resume. 166
undo. 165
window selection. 108
Epb. 461
Equations. 282
example. 282, 285
mseq. 199
update. 203
Equipotential relaxation. 42
Er. 273
Er (Sf option). 266
Er (Sfi option). 269
Error
input. 74
Eset. 129, 463
example. 464
ESETC. . . . . iv, 470
Eseti. 464
esh. 419
eshi. 419
Esm. 194, 231
3D curves. 222
esmp. 234
example. 233, 234, 256, 264
hierarchy. 194, 204
intro. 23
Esmp. 234
esm. 232
example. 234, 256
esquah
rivet hole. 412, 416
etd
usage. 439
Examples. 26
Examples Manual. 25
Exec button. 170, 171
red. 172
Exec/Quit button. 102, 167, 170
red. 172
Execute line. 56
Executing dialogue box. 171, 173
character. 173
Execution. iii
Exit. 62
button. 62, 72, 73
menu button. 72
Exit button. 62
Exp
Expressions. 284
Expressions
Fortran, format. 170
Extrusion
project. 267, 270
F1 Key. 36, 95, 96, 102, 172, 213, 214
intro. 65
F10 Key. 172
F2 Key. 95, 96, 102, 172
command. 300
intro. 65
F3 Key. 172, 288
F4
line thickness. 82, 83
F4 Key. 172
F5 Key. . . 94, 124, 126, 143, 144, 150, 172,

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

175
F6 Key. 94, 124, 126, 172
F7 Key. 112, 122, 125, 172
F8 Key. 112, 172, 207
F9 Key. 122, 172
Fa. 332
Face. 32, 94, 123, 231
attaching. 152
create, set. 132
intro. 46
movement. 143
orientation, set. 133
projection. 40
selection. 95, 103
Face (Sd option)
intro. 23
Face ID. vi
Face set. 129
comment. 470
delete. 463
modify. 130, 465
Faces. 37
Faces Button. 130
Faceset (Sd option)
intro. 23
Fai. 333
Fast Gr. 105, 106
aad. 75
ad. 75
caption. 76
daad. 76
dad. 76
dads. 77
display. 77
draw. 77
pad. 78
poor. 79
postscript. 80
raad. 80
rad. 80
tvv. 85
Fast Graphics
SPH. v
FAX. 24
Fbc. 349
Fbci. 350
FC. . . . . iii, 333
Fcc. 334
Fcci. 335
Fci. 334
Fcs. 336
Fcsi. 336
FD. . . . . iii, 301
fdsi. 305
Fdc. 302
Fdci. 303
Fdi. 301
Fds. 304
fdsi. 305
Fdsi. 304
file names. 63
Fill. 148
button. 106
option. 87
pick by projection. 122
pick point. 122
sdint. 81
Fill button. 66
postscript. 80
tvv. 85
Fix. 90, 93
rx. 89
Fl. 368
orpt. 201
Fli. 368
oprt. 201
Floating point. 170
Flowint. 395
Flowinti. 396
Fluid flow
boundary conditions. 371
Flux
boundary conditions. 368, 369
fl. 368

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

fli. 368
Fn. 458
example. 459
Fni. 460
Fogging. 106
Font. 57, 61
name. 57
FOR. iv
Force. 326
format. 27
Fortran
equations. 282
Fortran interpreter. 170
Frame. 86
button. 109, 110
Frame button. 108
Frame of reference. 448
Frb. 306
Frbi. 306
From button. 176
Front View button. 145, 164
Fset. 129, 133, 465
example. 466
FSETC. . . . . iv, 470
Fseti. 133, 466
example. 467
Ft. 369
Ftf
Lct. 449
Tr. 209
Tri. 210
Fti. 370
Full indices. 33, 36
History. 290
Function (SD option)
example. 258
Fv. 307
Fvc. 309
Fvci. 309
Fvi. 308
Fvs. 310
Fvsi. 310
Fvv. 317
Fvvc. 319
Fvvcl. 320
Fvvi. 318
Fvvs. 321
Fvvsi. 321
Gaps. 38, 63
Gct. 451
Generating a New Picture. 108
Geometric indexing. 95
Geometric progression. 40
node spacing. 276
Geometric selection. 95
Geometry of the mesh. 27
geop. iii
NEK5000. . . . . vi, 420
nektol. 420
geopi
Nek5000. 420
nektol. 421
Getbb
savepart. 450
Global. 27
Global Button. 122, 143
Global Coordinates. 143
Gluings
supblk. 461
Gmi
grep. 455
Grab Text. 74
Graphical User Interface
intro. 22
Graphical user interface (GUI)
Turn off. 60
Graphics
color. 106
fogging. 106
lighting. 106
Graphics Commands. 75
undo. 166
Grayed out. 105
Grep. 30, 451, 454

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

lrep. 452
npm. 381
pm. 382
spring. 385
Greyed out. 108, 150
Resume button. 166
Grid. 78, 93
Gsii
grep. 455
GSview. 80
GUI. 56
intro. 22
GUI (graphical user interface). 26, 35
Hardware graphics
OpenGL. 105
Hardware graphics option. 105
Heat flow
boundary conditions. 371
Heat generation
vhg. 379
vhgi. 379
vvhg. 379
help. 27, 64, 70, 73
button. 72, 73, 170
getting. 28
menu button. 73
multiple. 24
on command syntax. 73
telephone number. 24, 28
Help window. 70, 73
quitting out of. 73
Hexahedral. 22
Hexahedron element. 22, 36
quality mesh. 266
Hfl. 371
Hfli. 371
Hidden line drawing
resolution. 92
Hidden line removal
poor. 79
Hidden surface remove. 105
Hide. 148
button. 92, 106
option. 87
pick by projection. 122
pick point. 122
Hide button. 66
disp. 77
Hierarchy
command. 287
Highlighting. 35
Edge, Face or Block. 125
history. 287, 289
of object by label. 120
of object by lasso. 120
of regions in computational window
. 94
the nearest vertex. 123
Histogram
measure. 445
History. 172, 288
Actcmd. 292
and update. 203
button. 166, 288
command. 102, 288
debug mesh. 123
Decmd. 292
dialogue box. 167
file. 58
region. 123
Table. 166, 267
window. 70, 102, 167
history table
tghist. 58
History window. 43
hole. 410
hyr. 235
I
equations. 284
I suffix. 94, 124
I-coordinate. 32
I-index. 29, 43, 50, 81, 95, 97, 241
intro. 46
Ibm. 425

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

intro. 22
Ibmi. 429
Ibzone. 95
zone. 104
IGES. 23, 62, 63, 138, 451
example. 66
file. 36, 62
intro. 23
IGES surfaces. 162
Igescd. 451
Igesfile. 138
Igespd. 451
Igessd. 451
Il. 353
Ili. 353
Ilin. 211
example. 212
hierarchy. 194, 203
Ilini. 212
example. 212
Include. 56, 63
command. 294
Index Bar. 81
Index bars. 50, 94, 104, 124, 138
default. 96
zone. 95, 104
Index progression. 47, 94, 123
attaching. 152
clear. 172
delete. 151
movement. 143
print. 172
selection, geometrical. 95
Indices. 32
History. 290
list. 33
show. 123
INGRID
compatibility. 267
Initial Coordinates. 194, 203
spherical projection. 271
Initial Coordinates 43
Initial mesh
and update. 202
update. 202
Initialize
3D curves. 217
Edge. 214
Initialize vertices. 37, 40, 43, 112, 152, 217, 266
Inizone. 371
Inizonei. 372
Inlet
il. 353
ili. 353
Input
file. 33
Input strings
in dialogue box. 169
Insert
button. 175
mode. 175
Insprt. 194, 195
3D curves. 216
Edge. 227
example. 197
surface edge. 155
tghist. 59
undo. 166
Installation directory. 26
Installing TrueGrid®. 25
Int
Expressions. 284
Integer. 170
Integration
beams. 425
Interactive. 56
Interactivity 42
interface. 408, 409
Interior node. 32, 40, 231
Interpolation. 230
Interior of surface display. 81
Interior projection. 245
Interpolation. 32, 36, 42, 194, 230, 276

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

along curves. 214
Beams. 425
Bi-linear. 237
default. 235
initial ilin. 211
initial ilini. 212
intro. 23, 46
linear. 235, 237, 243
modified linear. 238
nodal distribution. 275
parameter. 232
poor initialization. 275
spline. 246
Interpreter Fortran. 170
Interrupt. 26, 57, 58, 166
history. 289
usage. 450
Intersection
2 surfaces. 186
intro. 23
of 3D curves. 217
of surfaces. . . 37, 160, 162, 267, 269
Orthogonal plane. 269
surface & curves. 217
tangent surfaces. 160
Intp
surface and Stp. 423
Intra-part BB. 206, 207
esm. 232
example. 265
relax. 244
unifm. 262
Intyp
Insprt. 196
Inv
Lct. 449
Tr. 209
Tri. 210
IPIL
Automatic Parameters. iv
Iplan (Sf option). 266
Iplan (Sfi option). 269
Iss. 397
Issi. 397
IT2DC
Automatic Parameters. iv
Italicized
syntax. 55
J
equations. 284
J-coordinate. 32
J-index. 29, 43, 50, 81, 95, 97
intro. 46
Jacobian. 445
Jbm. 432
intro. 22
Jbmi. 434
Jd
jt. 351
Joint
jt. 351
Joint replication. 452, 455
Jt. 351
grep. 455
lrep. 452
K
equations. 284
K-coordinate. 32
K-index. 29, 43, 50, 81, 95, 97
intro. 46
Kbm. 437
intro. 22
Kbmi. 440
Key
Control A. 172
Control B. 168, 172
Control D. 173
Control E. 171, 173
Control F. 168, 173
Control P. 173
Control Q. 172, 173
Control U. 173
Control V. 168, 173
Control X. 171, 173

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Control Z. 167, 172, 173
Enter. 169, 171
F1. . . . . 95, 96, 102, 172, 213, 214
F10. 172
F2. . . . . 95, 96, 102, 172
F3. 172
F4. 172
F5. . . . . 94, 124, 126, 143, 144, 150, 172, 175
F6. . . . . 94, 124, 126, 172
F7. . . . . 112, 122, 125, 172
F8. . . . . 112, 172, 207
F9. . . . . 122, 172
shift. 109
Keyboard
commands. 105
Keystrokes
for geometric selection. 96
in dialogue box. 172
into which window. 168
Keywords. 55
kiva
boundary conditions. 355, 356
periodic. 386, 402
kiva3bc. 353
kiva3bci. 354
kiva3v
boundary conditions. 353, 354
kivabc. 355
kivabci. 356
L. 86, 87, 110, 111
both. 108
Label
button. 112, 173
print. 112
Label button. 67, 137
Labels. . . . . v, 111, 300
1D. 431, 435, 439
3d. 119
block boundary. 137
button. 112, 113
crvpt. 116
curve. 137
curve points. 300
nodes. 118
overlapping. 113
panel. 111, 207
part. 117
parts. 300
print. 172
sd. 114
Sdedge and Edge. 227
sdpt. 115
surface. 137
surface edge. 137
tvv. 85
Labels button. 137
Laplace differential equation. 42
Large curvature. 39
Lasso. 120
Geometric objects. 120
picking. 122, 137
sets. 134, 135
Layer. 36
LB. . . . . iii, 356
example. 459
Lbi. 357
Lcd
example. 66
Lct. 451
Lrep. 451
Lcv. 70
ld
ctbc. 424
intro. 23
Learning TrueGrid®. 26
Left Mouse Button. . . 86, 105, 109, 110, 120, 122, 131, 169
Len memory. 60
Lev. 451
Levct. 451
Level. 451
License Manager. . . . . iii, 25, 26
License Manager Manual. 25

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Licensing. 25
Lighting. 106
Limits
equations. 285
line. 63
numeric values. 64
parameters. 171
Lin. 30, 32, 41, 194, 235
example. 237, 254
hierarchy. 194, 204
hyr. 235
intro. 23, 46
invoked by hyr. 235
linear interpolation. 235, 243
Tf. 247
line. 40
ad. 75
length. 63
thickness. v
Line thickness
set. 82, 83
Line thickness setting. 83
Linear
Interpolation. 235, 237, 243
Lini. 30, 194, 243
Insprt. 196
LINUX. 25, 56, 63
List
Automatic Parameters. iv
end with ;. 64
Lists of numbers
in dialogue box. 169
Ll. 337
Lmi
lrep. 452
lmseq. 194
Load. 27, 326, 337
curve. . 112, 301, 308, 311, 313, 315, 333, 337
nodal. 301-303, 308, 333-336
nodal, fc. 333
nodal, fcc. 334
nodal, fcci. 335
nodal, fci. 334
nodal, fcs. 336
nodal, fcsi. 336
loads. 27
nodal. 309, 310, 332
Local approximation. 39
Local Button. 122, 143
local constraints. 360
Local coordinate system
display. 422
Local Coordinates. 143
Lofted curve
project. 267, 270
Log
Expressions. 284
log10
Expressions. 284
Lp3. . . . . 112, 145, 150
Automatic Parameters. iv
Lp3 (Curd option). 173
intro. 23
Lp3 button. 173
Lrep. 30, 451
grep. 452
npm. 381
pm. 382
spring. 385
Ls-dyna
Sc. 480
LSDYNA. iii
72REL3. iv
material. 477
READMESH. v
shell offset. 422, 423
Lsii
lrep. 452
Lsys. 451
example. 459
lb. 357
lbi. 357
Lv. 70

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Lvc. 70
Lvi. 70
M
Mt. 471
Ma. 212
example. 213
Machine ID. 25
Magnetic flux
boundary conditions. . . 371, 374-378
Main menu. 72
Manual
Examples. 25
License Manager. 25
Output. 25
Tutorial. 25
User's. 25
map
bb. 388
bb option. 386
trbb. 402
trbb option. 402
Mapped mesh. 272
Mapped method
plane. 39
Mark
ad. 75
mass
quadrature. 448
Mate. 471
bb. 391
example. 67
Material
0. . . . . 387, 425
Anisotropic. 422
coordinate system, display. 422
model. 471
number. 471
orientation. 418, 422
orthotropic. 421
zero. 477
material models. 27
Material number
and replication. 452, 455
Max
Expressions. 284
Maximum reduced index. 47
maxmea
parameter. 445
Mb. 30, 37, 194, 204
example. 66, 205
hierarchy. 194, 203
intro. 23
Mbb. 138
Mbi. 30, 144, 205
command. 194
example. 206
Mdep. 338
Mea. 445
intro. 23
shape functions. v
VIGQ. v
Meai. 447
Mean. 285
parameter. 445
Measure. iv
example. 67
histogram. 445
mea. 447
shape function. 445
shape functions. v
vigq. 446
MEASURES
VIGQ. v
Memory. 60
Menu
in dialogue box. 168
main. 72
q. 72
System. 105
Merge. 27, 30, 60, 62
coincident. 159
endpart. 450
example. 67
intro. 64

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Parts. 30
phase. 62, 106
Merge phase. 65
Mesh
density. 33, 199
initialization. 152
partitions. 44
quality. 445
Mesh (Sd option)
intro. 23
Mesh Parameterization 44
Mesh quality. 217
Avolume option. 446
dli. 447
dlj. 447
dlk. 447
dvi. 446
dvj. 446
dvk. 447
Jacobian option. 446
Orthogonal option. 446
Pointvolume option. 446
Smallest option. 446
subvol. 447
Volume option. 446
warp. 446
Mid button. 130
mid-plane
variable thickness. vi
Middle Mouse Button. 86, 109-111, 172
motion. 108
Min
Expressions. 284
Minimum reduced index. 47
minmea
parameter. 445
Mod
Expressions. 284
Modify mesh command. 289
mof. 63
MOM. . . . . iii, 339
Moments
mom. 339
momi. 340
Momentum deposition
curve. 338
Momi. 340
Mouse
left button. 74, 95, 102
middle mouse. 74
right button. 80
Move. 86
3D Curve. 150
button. 109, 110
by constraint. 149
front view. 148
polygon surface. 150
region. 152
Regions of the Mesh. 143
screen plane. 147
Move button. 108
Move Pts. 205
Move Pts. button. 173
Mp. 380
MPACT. iii
MPC
MPCINFO. vii
MPCE. iv
constraint equation. vii
MPCINFO
MPC node sets. vii
Mpi. 380
Ms. 273
hierarchy. 194, 203
Mseq. 32, 33, 194, 199
equations. 199
example. 200
tghist. 60
undo. 166
update. 199, 202
Mt. 471
bb. 391
example. 67
Namreg. 358

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Mti. 471
Autodyn. 471
bb. 391
MTV. . . . . vi, 471, 476
Multi-block. 22
Multiple Block Structured Parts. . 33, 36, 40, 193
Multiple regions. 231
esm. 232
relax. 244
Mx
Lct. 448
Tr. 208
Tri. 210
My
Lct. 448
Tr. 208
Tri. 210
Mz
Lct. 448
Tr. 208
Tri. 210
N. 421
oprt. 201
orientation. 422
Namreg. 358
Namregi. 358
NASATRAN. iii
NASTRAN. 326
READMESH. v
shell offset. 423
spc. 346
Natural Derivatives. 181
ndd
as. 279
nds. 279
Ndl. 340
oprt. 201
Ndli. 341
oprt. 201
Nds. 279
command. 248
cur. 224
dndd. 281
edge projection. 269
esm. 232
Lin. 235
ndd. 279
relax. 243
Tf. 248
Tme. 253
NE/NASTRAN
spc. 346
NEK5000. iii
geop. . . . . iii, vi, 420
geopi. 421
nektol. 421
nektol
NEK5000. 421
NERL. iii
Network. 26
Neu. 257
Neui. 261
example. 259
Neumann condition
neu. 257
neui. 261
Newton method. 37, 39, 221, 268
nextbb. 386
nextmat. 470
NIKE3D
tepro. 377
Nint
Expressions. 284
nodal
distribution. 279
nodal distribution
dndd. 281
Nodal loads. . . 301-303, 308-310, 332-334, 336
Nodal rotation
frb. 306
frbi. 306
Node

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

attaching to. 152
button. 113, 173
create, set. 131
distribution. 275
labels. 111
merging sliding interface. 398
movement. 143
number. 123
print block, npb. 461
rotation, frb. 306
selection. 93
spacing. 276
Node Button. 123, 144
Node set. 129
comment. 469
delete. 463
info. 470
modify. 130, 467
nodes
add. 199
Nodes Button. 130
Nogui. 56
intro. 22
Nonreflecting boundaries
nr. 358
nri. 358
Norm
Expressions. 285
Normal mode of text window. 74
Normal to surface
setting. 200
normal vector. 361
Normal vectors
n. 421
shell. 418
Npb. 461
Npm. 381
pm. 382
spring. 385
Nr. 358
Nri. 358
Nset. 129, 467
example. 444
NSETC. . . . . iv, 469
Nseti. 468
example. 469
Nsetinfo. 467, 470
Numbers
format. 170
in dialogue box. 169
minimum and maximum allowed. . . 64
NURBS
surface. 38
Nurbsd. 451
Off
button. 113
Offset
coordinates. 204, 205
dialogue box. 168
Ol. 358
Oli. 359
Open Curve button. 191
Open Set Button. 129
OpenGL. 25
aad. 75
ad. 75
caption. 76
daad. 76
dad. 76
dads. 77
display. 77
draw. 77
H.W. button. 106
hardware graphics. 105
pad. 78
poor. 79
postscript. 80
raad. 80
rad. 80
slice. 83
tvv. 85
Option
cmd_file. 58
display. 61

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Fill. 106
font. 61
H.W.. 106
hire. 106
in dialogue box. 168
len. 60
nogui. 60
output_file. 60
tsave_file. 58
wire. 106
Or. 422
element set. 463
face set. 465
node set. 467
Order of executing commands
mesh. 253
relax. 244
unifm. 262
orientation
brick. 422
material. 418, 422
orpt. 201
shell. 422
surfaces. 200
Orpt. 133, 200, 365
beam. 428
cvt. 367
hfl. 371
Ndl. 341
Pr. 343
Rb. 374, 375
re. 376
shell normal. 421
si and sii. 385
orthogonal
mesh. 253, 255
neu. 230
neui. 257, 261
Neumann. 230
plane. 269
unifm. 230, 258
Orthogonality. 445
Orthotropic
material. 421
Outlet
Ol. 358
oli. 359
Output. . . . . iii, 27
Output file. 60
Option. 60
Output Manual. 25
Over-constrained
nodal distribution. 275
Overlapping. 38, 63
Pa. 213
example. 214, 263
Pad. 78
ad. 75
Page Down key. 73
Page Up key. 73
Parabola. 273
Paraboloid
project. 266, 270
Parameter
maxmea. 445
mean. 445
minmea. 445
standev. 445
Parameters. 33, 170
example. 263, 264
limits. 171
of execution of TrueGrid. 57
usage. 171
Parametric. 144
face sets. 133
intro. 22
sets. 129
Parenthesis. 170
Parser. 170
Part. 30, 33, 62
button. 27, 113
cylinder. 144
Initialization. 37
number, display. 111

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

numbers. 300
phase. 62, 70
Part Button. 138
Part phase. 65
Part Transform
TRPRT. v
Partition. 81, 124, 151
add. 195
insprt. 196
mesh. 33
Partmode
example. 264
Patch. 194, 265, 272
attaching. 152, 153
hierarchy. 194, 203
path names. 63
Pb. 30, 37, 144, 157-159, 194, 206
attaching. 152, 153
example. 66, 207
hierarchy. 194, 203
Insprt. 197, 198
intro. 23
projection. 266
tghist. 59
pbs. 37, 194, 207
attaching. 152, 153
example. 208
hierarchy. 194, 203
periodf
bb option. 386
trbb option. 402
periodp
bb option. 386
trbb option. 402
Perspective. 86, 92, 106
Perturbation. 40
Phys. 108
Phys button. 108
Physical mesh. 29
Physical window. 70, 86
Pick
3D Curve. 137
block boundary. 120, 137
button. 112
by label. 120, 137
coordinates. 125, 152
curve. 120, 137
Edge. 137
Gobal coordinates. 122
node. 123
panel. 120, 207
partial coordinates. 125
point by projection. 122
point by Z-buffer. 122
region. 125
sets. 129
surface. 120, 137
surface edge. 120, 137
vertex. 123
visible point. 122
with lasso. 122
Pick
local coordinates. 122
Picture
Choosing the Type of. 105
Picture Controls. 86
Pipe. 174
Pl3 (Sf option). 266
Plan. 273
stone wall. 363, 364
symmetry constraint. 346
symmetry w/ failure. 364
Plan (Sf option). 266
Plan (Sfi option). 269
Plane. 273
project. 266, 269
stone wall. 363, 364
symmetry w/ failure. 364
Pm. 382
npm. 381
spring. 385
Pn. 144
Point
3D Curve. 122

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

attaching to. 152
display labels. 300
surface. 122
surface edge. 122
Point List Button. 145
Point List window. 112, 150, 173
Point mass
npm. 381
pm. 382
Poly Surf. Button
polygon surface. 150
Poly Surface Button. 144
Polygon set. 129
Polygon sets
create. 135
Polygon surface
modify. 143
polygon set. 129
Polygonal line. 38
Polygons button. 130
Poor. 77, 79
display. 77
draw. 77
tvv. 85
Poorman's algorithm. 77
Pop-up Window. 80
Por. 480
Pori. 480
postscript. 63, 79
disp. 77
draw. 77
GSview. 80
line thickness. 83
poor. 79
resolution. 92
tgimage.ps. 80
Pplv. 30, 451
PR. . . . . iii, 273, 342
example. 67
orpt. 201
Pr (Sf option). 266
Pr (Sfi option). 270
Pramp. 344
precision
double. 106
single. 106
Prepend button. 175
Prescribed
boundary. 306
Pressure. 326, 342
pr. 342
Pri. 343
Pri. 343
orpt. 201
progression
notation. 55
selection, geometrical. 95
Project. 70, 120, 153
attach. 219
button. 30, 112, 122
shell. 423, 424
tangent surfaces. 221
to 1 surface. 220
Project button. 67, 152, 158
Projected node. 38
Projection. . . 27, 32, 160, 186, 194, 265, 276
3D curve. 158
3D curves. 269
algorithm. 267
button. 112, 122, 158, 164, 173
curve. 122
directional. 270
edge. 269
error. 38
esm. 231
ignored by tf. 247
il-defined. 268
Interpolation. 230
method. 37, 38, 194
move. 164
multiple surfaces. 232
pre-positioning vertices. 203
relax. 243-245
spherical. 270

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

surface. 122, 158
surface edge. 122
three surfaces. 160
two surfaces. 160, 162
Projection method. 143, 152
attaching. 153
intro. 23
Prompt. 74, 169
blue. 172
properties. 27
Pset. 129
Pslv. 30, 451
npm. 381
pm. 382
spring. 385
Ptol
npm. 381
Pvpn. 150
Q. 30, 45, 194, 214
example. 214
hierarchy. 194, 203
Q-Bricks button. 113, 130
Q-Shells button. 113, 130
qconcav
rivet hole. 418
qcritang
rivet hole. 418
qrefnn
rivet hole. 418
qresolve
rivet hole. 418
Quadratic. iii
equations. 284
quadrature
mass. 448
Quadrilateral. 22
shell element. 22
Quality mesh. 42
Quality Meshes 42
Quit Button. 129, 176
Quitting out of dialogue box. 171
R. 86, 87, 110, 111
both. 108
R3dc. 174
Raad. 80
Rabb. 138, 394
Racd. 138
Rad. 80
Radians. 285
Radiation
boundary condition. 374
boundary conditions. 374
enclosure. 376
Raixs
Lct. 448
Rand
Expressions. 285
Rasd. 138
Raxis
Tr. 209
Tri. 210
Rb. 374
oprt. 201
Rbb. 138, 393
Rbbs. 138, 393
Rbi. 374
oprt. 201
Rcd. 138
Rcds. 138
Re. 376
oprt. 201
Re-project. 37
Reactivate. 43
READMESH. . . . . v, 63
Rebar. 428
embedded. 425
Rectangular block. 36
Reduced index
negative. 50
Reduced indices. 33, 35, 45
add. 195
History. 290
label. 81
structure. 94, 123

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Reference grid. 78
REFLEQS
inizone. 371
inizonei. 372
setsori. 373
REFLEQS,Por. 480
REFLEQS,Pori. 480
Reg. 359
Regi. 360
Region. 32, 94, 123
attaching. 152
button. 124
clear. 172
default. 143
delete. 151
movement. 143
notation. 55
print. 172
selection, geometrical. 95
selection, graphical. 94, 124
Region button. 125, 137, 144
Registration. 25
Rei. 376
oprt. 201
Reissue commands. 74
Relative arc length. 248
Relax. 30, 42, 194, 231, 243
3D Curves. 222
delete example. 245
example. 233, 244, 255, 263
hierarchy. 194, 204
nodal distribution. 275
tme. 253
relaxation. 243, 261, 265, 276
about hole. 245
Thomas-Middlecoff. 252
Relaxi. 30, 194, 246
tme. 253
Remarks. 55
Remove
elements. 199
Remove button. 130, 137, 138
Replications
global. 451
level. 451
local. 451, 454
Rerun. 33
Res. 30, 275
as. 278
Cur. 224
edge projection. 269
esm. 232
example. 277
Hyr. 235
invoked by hyr. 235
Lin. 235
relax. 243
Splint. 247
Tf. 248
Tme. 253
Reso. 92
Resolution. 92
Rest button. 93, 108
Restore. 86, 93, 146
grid. 78
zclip. 86
Resume. 57, 166
button. 26, 166
Retrieve
3D curve. 185
Return Key. 74
rfholes
rivet hole. 412, 414
Rg. 138, 298
Rgi. 138, 298
Rgrp. 139
Rindex. 81
rivet hole. 410
Rlv. 139
Rm. 138
Mt. 471
Rms. 138
Rotate. 70, 86
button. 109, 145

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

mesh. 146
picture. 109
Rotate button. 108
Rotation. 324
center. 90
ve. 325
velocity. 325
Row. 36
Rp. 138
Rpic. 110, 111
Rps. 138
Rrg. 138, 298
Rrgi. 138, 299
Rsd. 138
Rsds. 138
Rule3d. 174
Running TrueGrid®. 55
Rx. 86, 88, 146
both. 108
fix. 90
Lct. 448
rotate picture. 110
Tr. 209
Tri. 210
triad. 85
Rxy
Lct. 449
Tr. 209
Tri. 210
Rxz
Lct. 449
Ry. 86, 89, 146
both. 108
fix. 90
Lct. 448
rotate picture. 110
Tr. 209
Tri. 210
Ryz
Tr. 209
Tri. 210
Rz. 86, 89
both. 108
fix. 90
Lct. 448
rotate picture. 110
Tr. 209
Tri. 210
Rzx
Lct. 449
Tr. 209
Tri. 210
SAJEL. iv
Save
set. 129
tsave file. 33
Save As Button. 129
Save button. 176
saveiges. 63
Savepart. 450
Sc. 480
Scale. 90
Scope
command. 288
History. 291
Screen Plane button. 145
Scroll arrows. 73
Scroll mode
of text window. 74
Scrolling. 73, 172
in dialogue window. 167
Point List. 182
scv
cycorsy. 448
Sd. 36, 63, 138, 266, 273, 451
beam. 428
blend3. 174
blend4. 174
composite surface. 174
crule3d. 174
display surface numbers. 300
example. 66
function. 258
intp. 424

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

intro. 23
pipe.. 174
pipe example. 215
r3dc. 174
rule3d. 174
sds. 39, 63, 174, 189, 266
sds example. 216
sfi. 267
undo. 293
Sd (Sf option). 266
Sd (Sfi option). 269
Sdedge
(Curd option). 155
Sdedge (Curd option). 174
intro. 23
Sdint. 81, 112, 136, 139
edge. 189, 227
Sds. 174, 189
Sd option. 266
Sds (Sd option).. . . . . 39, 63, 267
intro. 23
Sds (Sf option). 266
Sds (Sfi option). 269
Se (Curd option).. 174
Seed. 285
Selection
control point. 172
multiple regions. 231
node. 172
of Edges. 52
of Faces. 52
of Volumes. 51
regions and progressions. . . . 70, 95, 172
Session file.. . . . . 33, 144, 150-152
intro. 22
SET.. . . . . v, 81
thick. 79
tv.. 439
Set Editing. 129
add. 130
beams. 130
bricks. 130
clear. 130
mid. 130
Nodes. 130
Open Set. 129
polygons. 130
q-bricks. 130
q-shells.. 130
Quit.. 129
remove. 130
Save As. 129
shells. 130
toggle. 130
Set identification.. 346
Sets
add to. 130
beam. 130
brick. 130
create, beams. 133
create, face. 132
create, node. 131
create, polygon. 135
create, shells.. 134
element. 129
face.. . . . . 129, 130
faces. 130
node. 130
nodes. 129
polygon.. 129
quadratic brick. 130
quadratic shell. 130
remove from. 130
shell. 130
surface polygon.. 130
Sets Button
polygon.. 129
Setsor. 373
Setsori. 373
Sf. 30, 36, 41, 94, 124, 194, 266
example. 67
hierarchy.. . . . . 194, 203
intro. 23

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

ms. 274
projection. 266
Tf. 247
sfasprat
rivet hole. 418
Sfb. 360
edges. vii
oprt. 201
Sfbi. 362
oprt. 201
Sfi. 30, 94, 124, 160, 194, 269
ms. 274
projection. 266
sfmxpled
rivet hole. 418
Shape function
Measure. . . . . v, 445
Shell
2D. 36
from solids. 419
material orientation. 418
normals. 202, 421
orientation. 422
outward normal. 418
thickness. 418, 419, 423-425
Shell Offset. iv
co thic. 423
shoff. 422
shoffi. 423
shell to solid. 408, 409
shelli
shell offset. 423
Shells
button. 113
create, sets. 134
face set. 133
labels. 111
triangle. 159
variable thickness. v
Shells Button. 130
Shift key. 109
SHOFF. iv
shell offset. 422
Show. 120, 123
Show All button. 137, 138
Show Button. 123
Show None button. 137, 138
Show Only button. 137, 138
shtoso. 408, 409
Si. 397
example. 67
orpt. 201
sid
beam. 428
dialogue box. 168
example. 66
rebar. 443
set identification, constraints. . . . 346
si and sii. 385
Sign
Expressions. 284
Sii. 398
orpt. 201
Simple line drawing. 105
Sin
Expressions. 284
Sinh
Expressions. 285
Size. 57, 60
Slice. 85
dialogue. 84
Slice button
slice. 83
Slicing Planes. 173
Sliding interface
display. 399
number and replication. 452, 455
rebar. 443
viewing. 398
Smallest. 445
smallest edge
rivet hole. 412
Smoothing. 23
across boundaries. 231

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

cubic splines. 246
elliptic. 231
equipotential. 243
intro. 23
nodal distribution. 275
Thomas-Middlecoff. 252
tme. 254
triple vertex. 231
uniform. 261, 262
Smoothing constraint
Sc. 480
Sort
History. 290
Sp (Sd option). 273
Sp (Sf option). 266
Sp (Sfi option). 270
SP4PT. vi
spaces. 63
Spacing
nodes. 269
sparticle
material. 477
Spd
dialogue box. 168
spring. 385
Spdp. 382
Specifying Multiple Blocks 43
SPH
graphics. v
material. 477
Sphere. 273
project. 266, 270
SP4PT. vi
Spherical projection. 270
Spline. 145, 150
Automatic Parameters. iv
curve. 112
derivatives. 181
example. 66
Spline button. 173
Splint. 156, 194, 246
example. 211, 254
hierarchy. 194, 203
Split region. 195
Split screen mode. 74
Spp. 270
example. 272
hierarchy. 194, 203
Spring. 383
npm. 381, 382
Sqrt
Expressions. 284
SSF. . . . . vi, 194, 418, 423
hierarchy. 194, 203
Ssfi. 194, 418, 424
St. 30
Standard deviation. 285
standev
parameter. 445
Stereo Lithography
STL. vi
Stiffness. 445
STL. vi
stlsd. 63
Stone walls
node selection. 363
Stp. 30, 159, 398
example. 67
measure. 445
npm. 381
Strghl. 299
Strghli. 299
Submenu. 72
Supblk. 461
flowint. 396
Superposition
in geometric selection. 100
Surf Edge button. 113, 137
Surf Point button. 113
Surface. 36, 39, 194
attaching to. 152
button. 113, 137
composite. 39
convex boundary. 216

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

definition. 273
display numbers. 300
edge. 111, 189
edge identifier. 227
Edge numbering. 111
edge, attaching to. 152
gaps. 38, 63
Hermite. vi
interior display. 81
intersection. 37, 39, 266, 267
intersection algorithm. 38
intersection method. 39
labeled edges. 111
labeled points. 111
labels. 111
list. 291
mapping. 39
modify polygons. 143
multiple. 266
node. 32
numbers. 111
orientation. 200
overlapping. 38, 63
Point numbering. 111
polygon. 129
project. 266
sds. 266
tangent. 160
undo. 166
Surface Button. 138
Surfaces
tangent. 269
Surfaces button. 67
Sw. 363
Swi. 363
Syf. 364
Syfi. 364
Symmetry plane with failure
node selection. 364
Syntax. 55
Syntax checking. 171
T. 30
measure. 445
npm. 381
T1
update. 202
T1=. 286
domain. 283
hierarchy. 195, 204
T2
update. 202
T2=. 287
domain. 283
hierarchy. 195, 204
T3
update. 202
T3=. 287
domain. 283
hierarchy. 195, 204
Tan
Expressions. 284
Tangent
plane. 38
surfaces. 160
Tangent plane. 268, 361
projection. 269
Tangent plane 38
Tanget surfaces. 221
Tanh
Expressions. 285
TE. . . . . iii, 377
example. 459
Tei. 377
Telephone. 24, 28
Temp. 377
Temperature
boundary conditions. 369, 370
constant, te. 377
constant, tei. 377
constant, temp. 377
initial, tm. 378
initial, tmi. 378
initial, vtm. 378
initial, vtmi. 378

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

prescribed, ft. 369
prescribed, fti. 370
prescribed, vft. 370
prescribed, vfti. 370
profile, tepro. 377
Template
spp. 270
Temporary variables 42
Tepro. 377
Termination. 62
Tetrahedron. 22
ALLTETS. vi
element. 159
Text
dialogue box. 169
Text window. 74, 105, 144, 150, 151
mesh selection. 95
modes. 74
Text/Menu window. 70
Tf. 30, 42, 194, 247
intro. 23
Lct. 449
relax. 244
Tr. 209
Tfi. 30, 194, 252
example. 254
insprt. 196
relax. 244
transfinite interpolation. 247
Tg. 25, 106
TG Controls. 63
Tgauth
licensing. 25
TGControls. 57, 60
Tgd. 25, 106
TGDISPLAY. 61
Tgdx. 25
TGFONT. 61
tghist. 58
TGHOME. 25, 63
Tgimage.ps
postscript. 80
Postscript file. 80
tvv. 85
Tglm. 25
Tgw. 25
Tgx. 25
Th. 418
Thi. 418, 424
Thic. 418, 425
thick
set. 79
Thickness
Beams. 425
line. v
shell. 419
shells. 424, 425
shells, variable. 423, 424
SSF. 425
SSFI. 425
Th. 425
Thi. 425
Thic. 425
Thickness of lines. 83
Thomas-Middlecoff relaxation. 252
Title. 76
caption. 76
Tm. 378
Tme. 30, 194, 252
3D curves. 222
example. 255
Hierarchy. 194, 204
intro. 23
nodal distribution. 275
Tmei. 30, 194, 257
tme. 253
Tmi. 378
Tmplt. 272
example. 272
spp. 270
To button. 176
Toggle button. 130
TOPAZ3D
boundary conditions. 366-370

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Rb. 374, 375
Rbi. 374, 375
Re. 376
Topology. 193
change. 195
Topology of the mesh. 94, 123
Torus. 273
project. 266, 270
tp
measure. 445
npm. 381
Tr. 30, 37, 144, 194, 208, 451
example. 66, 210, 272
hierarchy. 194, 203
Tracer particles
trp. 364
TRACT. . . . . iii, vi
Traction
TRACT. vi
Trans. 89
Transfinite interpolation. 23, 42
Transform
region. 208, 210
Transformations
global. 451
Level. 451
local. 451
Transition regions. 401
Translate. 70, 143
3D curve. 150
by constraint. 149
coordinates. 205
front view. 148
picture. 86, 110
polygon surface. 150
region. 204
screen plane. 147
vertex. 212
Trbb. 194, 401, 451
attaching to. 156
hierarchy. 194, 203
intro. 22
order. 407
trbb. 408
Triquadratic. vi
Tri. 30, 194, 210
example. 211
Triad. 84
Trial license. 24
Triangle. 22
shell element. 159
Triple vertex
smoothed. 231
Triquadratic. . . . . iii, vi
Trp. 364
TRPRT
Transform Part. v
TrueGrid®
Execution Environment. 56
overview of windows. 70
Trugrdo. 60
Truncation. 170
Ts (Sd option). 273
Ts (Sf option). 266
Ts (Sfi option). 270
Tsave. 33, 144, 150-152
header. iv
intro. 22
Tsave file. 58
curd. 189
history. 289
Option. 58
pbs. 208
usage. 450
Tutorial manual. 25, 26
Tvv. 81, 85
disp. 77
poor. 79
Twsurf. 112, 145, 150
Automatic Parameters. iv
Twsurf (Curd option). 173
Twsurf button. 173
Typing into which window. 168
U. 110, 111

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

both. 108
Undo. 23, 165, 293
button. 153, 160, 166
Unfix. 90
fix. 90
rx. 89
Unifm. 30, 194, 231
3D curves. 222
example. . . 215, 233, 256, 258, 262, 265
example with &. 264
hierarchy. 194, 204
Neumann. 230
nodal distribution. 275
orthogonality. 230
Unifmi. 30, 194
Neumann. 230
orthogonality. 230
Unifrm
intro. 23
Unlock. 25
Up-arrow in text window. 74
Update. 202
equations. 203
example. 203
Mseq. 199, 202
useiges. 63
User's Manual. 25
V. 380
Lct. 448
Tr. 208
Tri. 210
Vacc. 321
Vaccc. 322
Vaccci. 323
Vacci. 322
Vaccs. 324
Vaccsi. 324
Variable Flux. iv
variable thickess
shells. 419
variable thickness. v
mid-plane. vi
Vcv. 366
Vcvi. 367
Ve. 325
rotation. 325
velocity. 325
Vei. 325
rotation. 325
velocity. 325
velocity. 307
boundary, bv. 311
boundary, bvi. 311
example. 66, 459
frb. 306
initial. 325
initial, ve. 325
initial, vei. 325
prescribed, fv. 307
prescribed, fvc. 309
prescribed, fvci. 309
prescribed, fvi. 308
prescribed, fvs. 310
prescribed, fvsi. 310
prescribed, fvv. 317
prescribed, fvvc. 319
prescribed, fvvci. 320
prescribed, fvvi. 318
prescribed, fvvs. 321
prescribed, fvvsi. 321
rotation. 325
ve. 325
Verbatim. iv
Verbose. 173
version. . . . . iii, 57
Vertec. 94, 123
selection. 95, 102
Vertex. 29, 32, 37
assign coordinates. 203
attaching. 152
control point. 246
movement. 143
notation. 55

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Regions. 45
VFL. . . . . iv, 369
Vfli. 369
Vft. 370
Vfti. 370
Vhg. 379
Vhgi. 379
Vi. 380
View
history. 290
vigq. 448
measure. 446
quadrature. v
Volume. 32, 445
Vpsd. 36, 63, 138
intro. 23
Vrb. 375
Vrbi. 375
Vtm. 378
Vtmi. 378
Vvhg. 379
Warpage. 445
Web site. 24
Wedge. 22
element. 159
Wedge element. 22
WHEN. iv
WHILE. iv
wiges. 63
Window
2D curves. 70
and keystrokes. 168
computational. 70, 94
dialogue. 70
environment. 70, 105
help. 70
history. 70
physical. 70
redraw setting. 108
text/menu. 70
WINDOWS. 24, 25, 56, 63
Wire
button. 105, 106
option. 87
pick by projection. 122
Wire button
draw. 77
poor. 79
Write. 60
example. 68
wrsd. 63, 150
WWW. 24
x
example. 282
X button. 145
X-coordinate. 29, 43
X=. 283
domain. 283
hierarchy. 195, 204
Xsca
Thickness. 425
Tr. 209
Tri. 211
XSCL. 90
scale. 90
XY button. 145
XYZ Scientific Applications. 24, 25
XZ button. 145
Y button. 145
Y-coordinate. 29, 43
Y=
domain. 283
hierarchy. 195, 204
Ysca
thickness. 425
Tr. 209
Tri. 211
YSCL. 90, 91
scale. 90
YZ button. 145
Z button. 145
Z-buffer
graphics. 123
pick point. 122

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved

Z-BUFFER button. 66, 173
Z-coordinate. 29, 43
Z=. 286
domain. 283
hierarchy. 195, 204
Zb. 86, 91, 110, 111
both. 108
Zf. 86, 92, 110, 111
both. 108
zb. 92
Zoom. 70, 86
button. 109, 111
Zoom button. 108
Zsca
thickness. 425
Tr. 209
Tri. 211
ZSCL. 90, 91
scale. 90
[
expressions. 170
in dialogue box. 171
]
expressions. 170
in dialogue box. 171

Copyright © 1992-2018 by XYZ Scientific Applications, Inc. All Rights Reserved