The Focus PADT
A Publication for ANSYS Users

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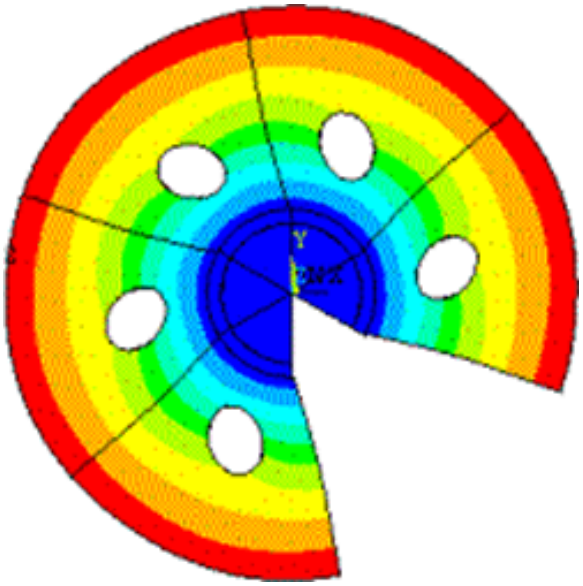

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Post-Processing Tips & Hints: Graphing in ANSYS

by Eric Miller, PADT

Post-processing is an oft-maligned part of the analysis process. Real analysts focus on meshing and running their models. But the fact is that getting meaningful answers is the whole point of doing a simulation. Spending a little bit of time to learn how to produce more concise and digestible results is a good investment. To this end, we will be covering a couple of key ways to produce higher quality results using POST1 and POST26 including listing, animation, sections, and for this second article, plotting to files for use outside of ANSYS.

We should start off by being honest; graphing is not the strongest capability in the ANSYS software. This is because so many fantastic graphing tools exist outside of ANSYS, and it is so easy to export your data to those programs (*vwrite). However, if you know the various options and commands for graphing with APDL, you can produce very useful information automatically as part of your analysis process, and in a much more timely manner than using the external programs. It is also often useful to combine graphs with contour plots or output information during a long solution. This article will cover how to create useful graphs and some hints on how to get more from graphing.

Graphing Basics

ANSYS provides support for two kinds of graphs: Bar and Line. If you are plotting data that has an X value (table arrays, time dependent results, path information), then ANSYS displays it as a line graph; but if the data is discrete, it uses a bar graph. Although bar graphs can be useful for histograms and for the display of statistical information, PADT has found that the vast majority of graphing is done using line graphs. So this article will focus on them.

One of the most important things to remember is that graphing is a subset of plotting in ANSYS, and all the view, output, and label commands that apply to plots of models and results also apply to graphs (see the previous article in this series for more information). You create the graph by issuing a specific result plot command that displays graph data such as PLVAR in POST26 or PLPATH to show path information. Or, if you make your own arrays, use the *VPLOT command. In addition to the standard plot controls, there is also a subset of tools that allow the user to control the look and feel of their graph.

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Controlling the look and feel

Figure 1 shows an example plot with most of the various controls used in the macro. We will use it to briefly explain the commands. For more information, please refer to the command manual.

```
/reset
/gfile,800
aa=
*dim,aa,table,10,3
aa(1,0) = 1,2,3,4,5,6,7,8,9,10
aa(0,1) = 1.1,2.2,3.3,4.4,5.5,6.6,7.7,8.8,9.9,10.0,10.0
aa(0,2) = 2, 0, 2, 2, 4, 4, 1, 1, 0, 0, 0.0
aa(0,3) = 3.4,8.1,7.3,2.5,3.1,3.1, 0,6.8,4.3, 1.3, 2.3
/grtype,1
/gthk,axis,3
/gthk,grid,1
/gthk,curve,2
/title,g2
*do,i,1,3
/gmarker,i,i
*enddo
/gcolumn,1,Force 1
/gcolumn,2,Force 2
/gcolumn,3,Torque
/xrange,1,10
/gropt,divx,9
/axlab,x,Time (Sec)
/axlab,y,Load Magnitude (Lbf & in-lbf)
/TSPEC, 15,1.5,1,0,0
/TLAB,-0.5, 0.85,Sample Plot of Loads on Nonexistent Model
*vplot,aa(1,0),aa(1),2,3
/annot,dele
```

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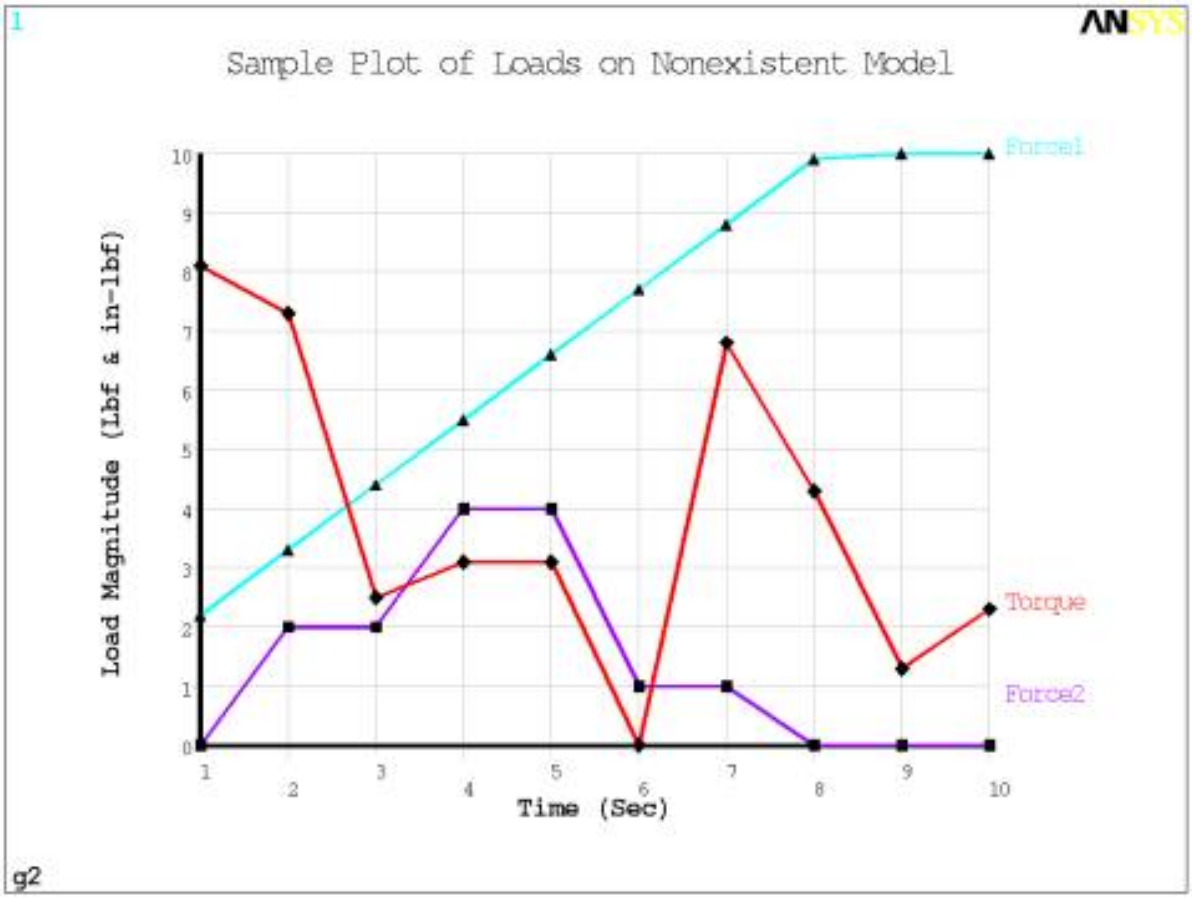

Figure 1.

The first command, /GTYPE,key specifies the style of graph. If key is 0 or 1, then all the data is plotted against a single Y axis. If it is 2, a Y axis is used for each curve, and if it is 3, then a 3D graph is created with separate Y axis. If you feel the need to use key 2 or 3, you should probably consider graphing outside of ANSYS.

The /GTHK,Label,Thick command is used to set line thicknesses for Label = Axis, Grid, or Curve. The default is twice the ANSYS standard thickness (Thick = 2). I have found that the values given in the example present the clearest graph. You should set the grid thickness to at least 1.

Another nice feature is that with the /GMARKER,Curve,Key,Incr command you can put squares, circles, triangles, and crosses on the data points, or on every Incr'th data point. This really helps clear up the graph and is useful to show the actual discrete data used. To further clarify what the curves are, use /GCOLUMN,Curve,String to label each curve. The default labels that ANSYS uses are often a bit brief, so replacing them with an 8 character string is a good idea.

By default, the X and Y axes will go from the minimum to maximum values being plotted. This can sometimes be confusing, so I like to use a combination of /XRANGE or

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/YRANGE with /GROPT,Divx or /GROPT,Divy to set the range and number of ticks to something that is easily read and digested. There are many other /GROPT commands that can be used to modify your plot, so you should read the manual on that command. One of the more common uses of this command is to set your axis to Log or Ln scale, or to set the precision of the numbers shown on the axis.

The last graphing control is one of the more important. The default naming of the axis can confuse people trying to decipher your graphs. It is always a good idea to use /AXLAB,Lab,String to give descriptive names. Note that unlike most commands, the %char% variable substitution does not work. The hint below gives a work around.

The final item in the example shows how to use ANSYS annotation to add a typical title to the top of the plot, rather than the standard /TITLE at the bottom. This can be extended to add arrows and text as well as your own legend.

Hint : Inserting Parameter Values into Axis Labels

If you want to have script that changes the axis labels on the fly you can not use %char% with the /AXLAB command. As a work around, write a macro in your macro using *vwrite to do the substitution. Here is an example:

```
n1 = 511
n2 = 518
path,pth1,2,30,30
ppath,1,n1
ppath,2,n2
pdef,p1us,u,sum,avg
pdef,p1s1,s, 1,avg
*cfopen,aa,inp
*vwrite,n1,n2
/axlab,X,Distance Btwn Nodes %g and %g
*vwrite,n1,n2
/axlab,y,Stress Btwn Nodes %g and %g
*vwrite,
/rmtemp
*cfclose
/inp,aa,inp
plpath,p1s1
padel,all
```

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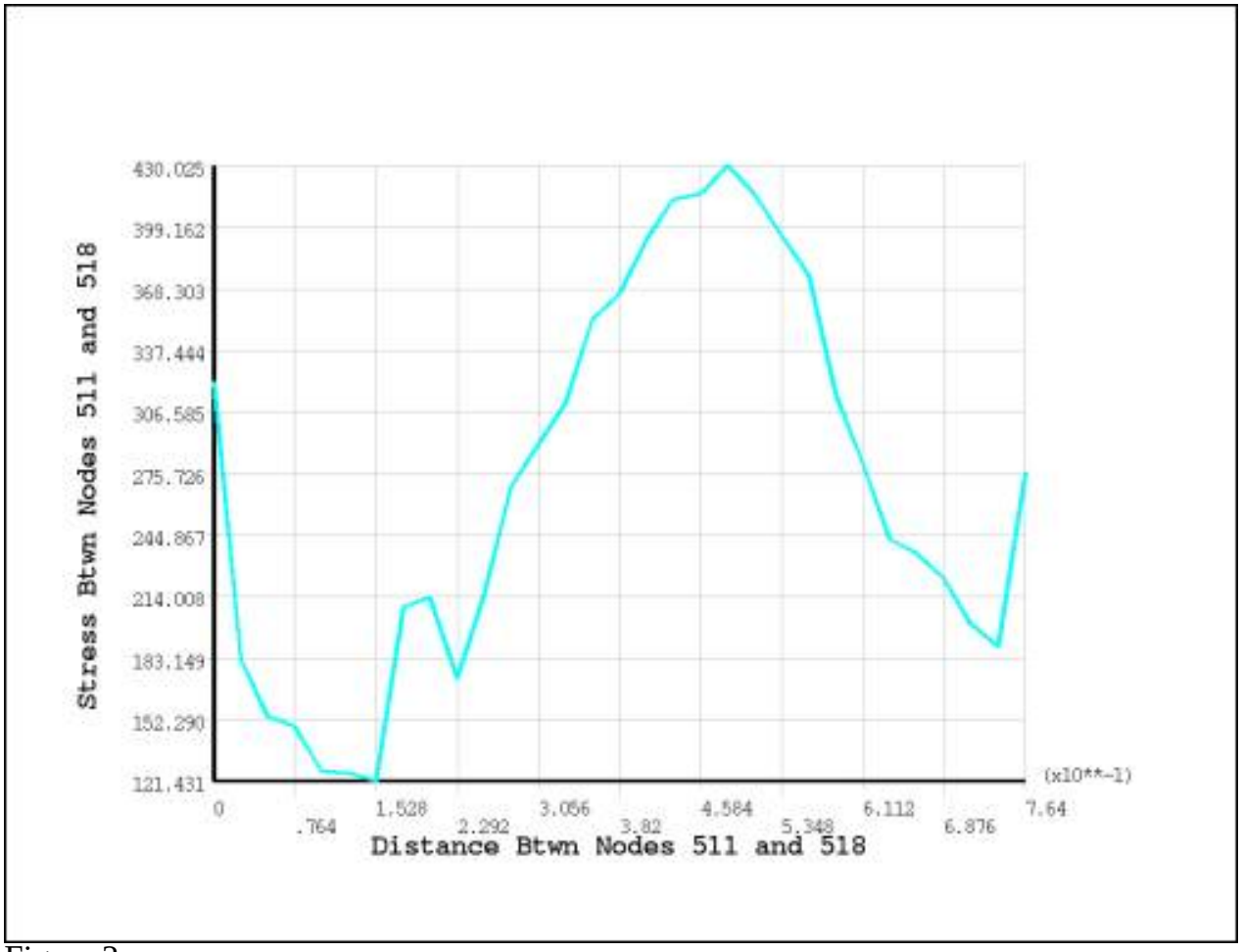

Figure 2.

Becoming an ANSYS Graphing Master

The key to getting fast with graphing in ANSYS is, like most things in ANSYS, APDL. You should develop one or more standard graph macros that setup your plot and set all of the style and label options. Having one for POST26 plotting is especially nice, since you often want to compare several result items at the same time.

Get to know all the options under /GROPT. There are many, and after you have played with them you will find that you can do a lot. Keep in mind that your goal is to display information in a concise and informative way, not to make high-quality scientific displays for your thesis. Ask yourself what you are trying to show with the graph, and then add only the control needed. Also, don't put too much on one graph. Use the ANSYS /win and /erase - /noerase functions to put multiple plots on one page (see the previous article on post-processing for an example).

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Getting Fancy with Animation

A sure sign of ANSYS plotting mastery is when you animate your plots in a sub window of an animation. Using arrays you can show the status of key values over time as you animate the behavior in the plotting windows. This has proved to be a wonderful tool for such non-linear behavior as plasticity, creep, and thermal transients. We will cover animation, including graphing, in the next issue of *The Focus* .

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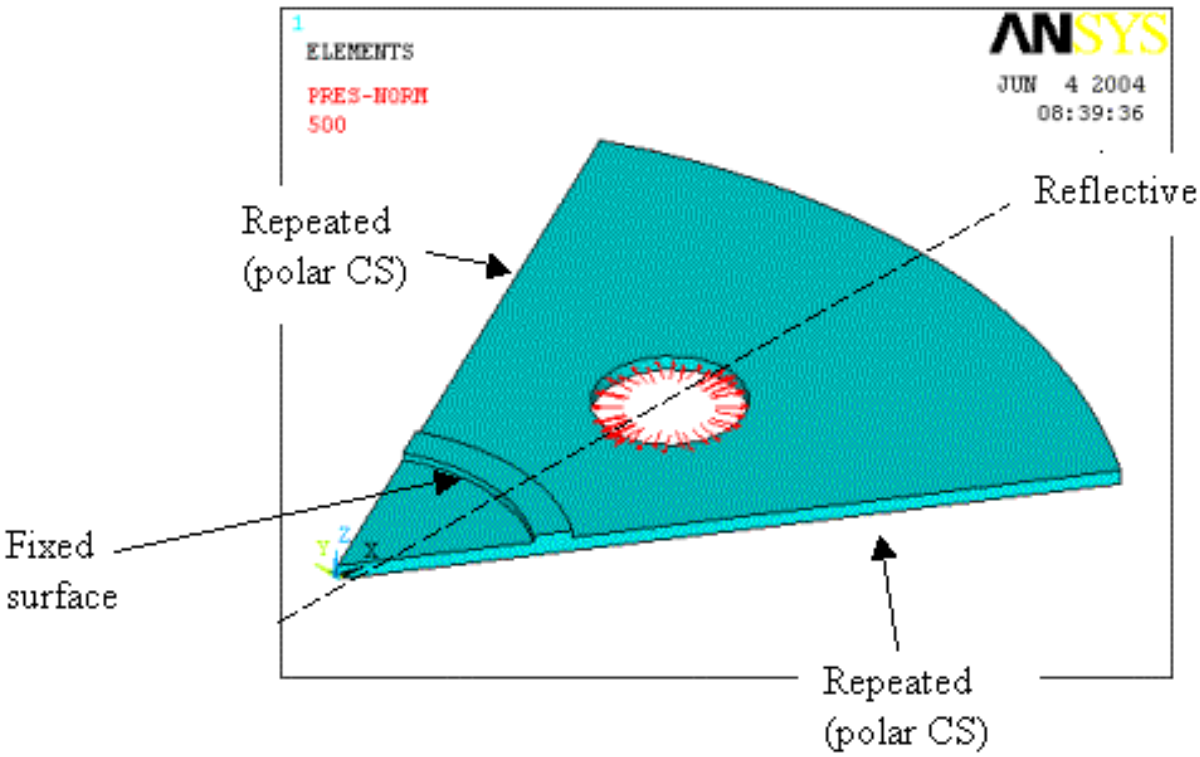
What Is Cyclo-Symmetry, Anyway?

by Rod Scholl, PADT

It doesn't take long using FEA to appreciate the value of a symmetry plane. However, there is a type of symmetry that is often over-looked – and that is cyclo-symmetry. When I first heard the word, I just nodded sagely…. Then when asked if I knew what it meant, I gave one of those nodding, shaking, circular head moves which, in engineer-speak means "I haven't a clue." Thankfully, the concept is easy to understand.

For a simple wedge, most analysts recognize the symmetry boundaries in the following standard symmetry case:



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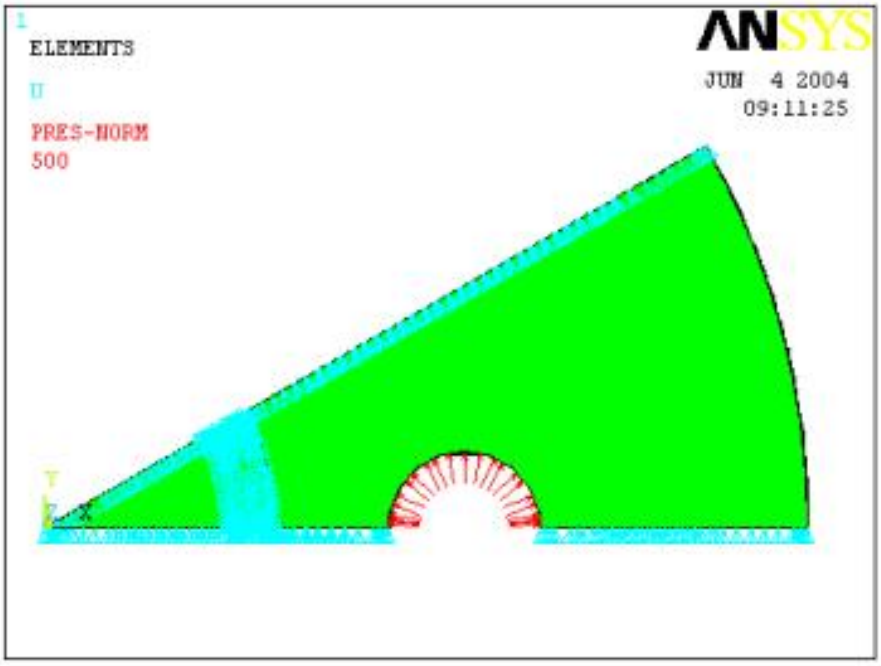
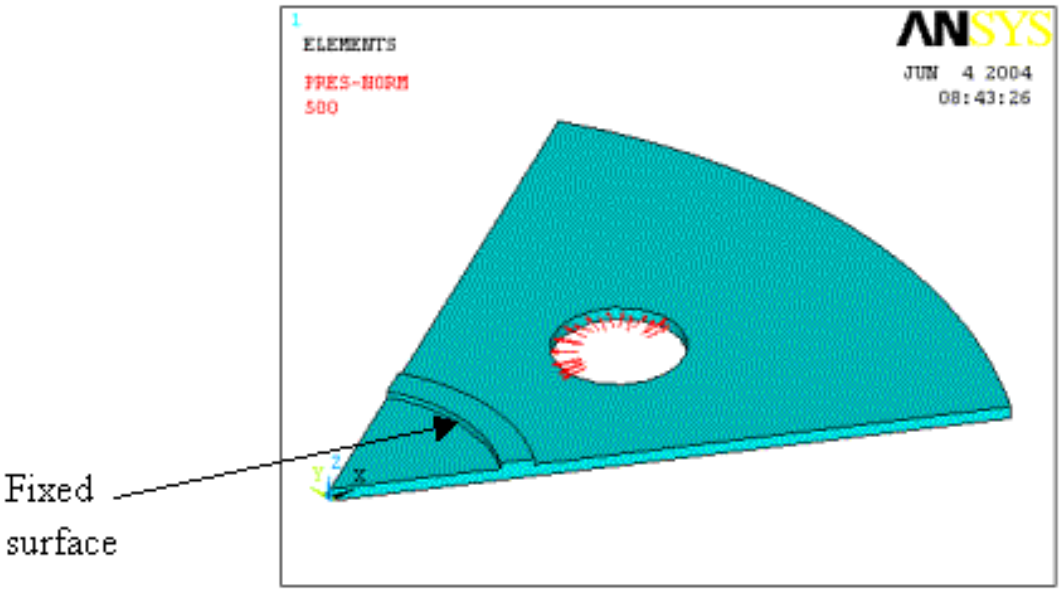


But what about the following case?



Now the center reflective symmetry in the center no longer applies, but what about the edges? Reflective symmetry no longer applies, either. The solution looks as follows (with exaggerated displacement scaling).

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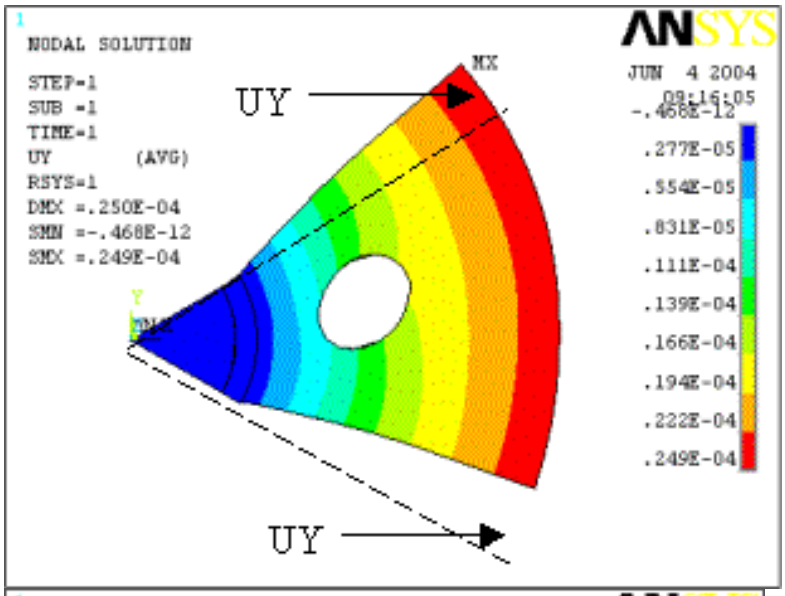

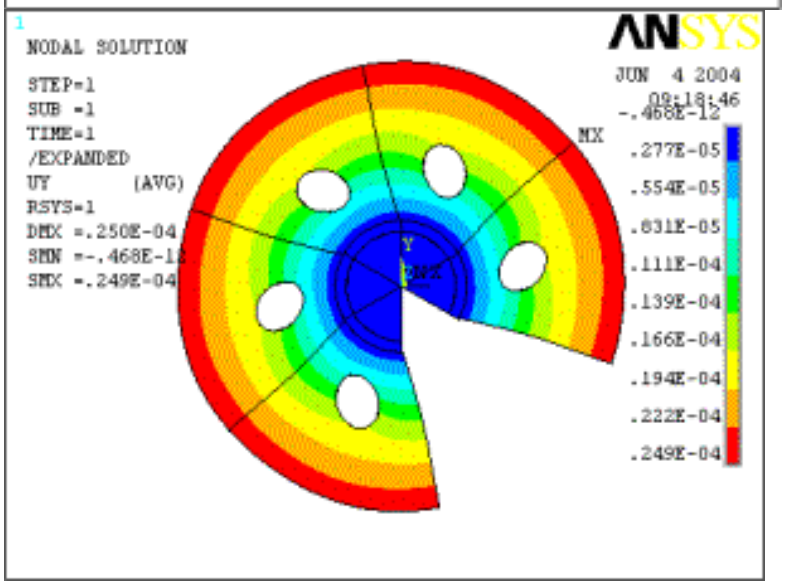

So clearly we can't fix the edges in the cylindrical UY direction. This is where cyclo-symmetry comes in. Instead, we couple one side's UY deflection to the other so that if the right side moves an inch in UY, then the left side moves the same amount…. The /EXPAND'ed image helps clarify.

So to couple one side to the other it is best to make sure the meshes match (MSHCOPY), then use the menu pick (Main Menu > Preprocessor > Coupling/Cegn > Offset Nodes) or the CPCYC command.

CPCYC, *Lab*, *TOLER*, *KCN*, *DX*, *DY*, *DZ*, *KNONROT*

By specifying a cylindrical coordinate system (*KCN*) and a wedge spacing (*DY)* in degrees, ANSYS will find your wedge boundaries and couple them for you!

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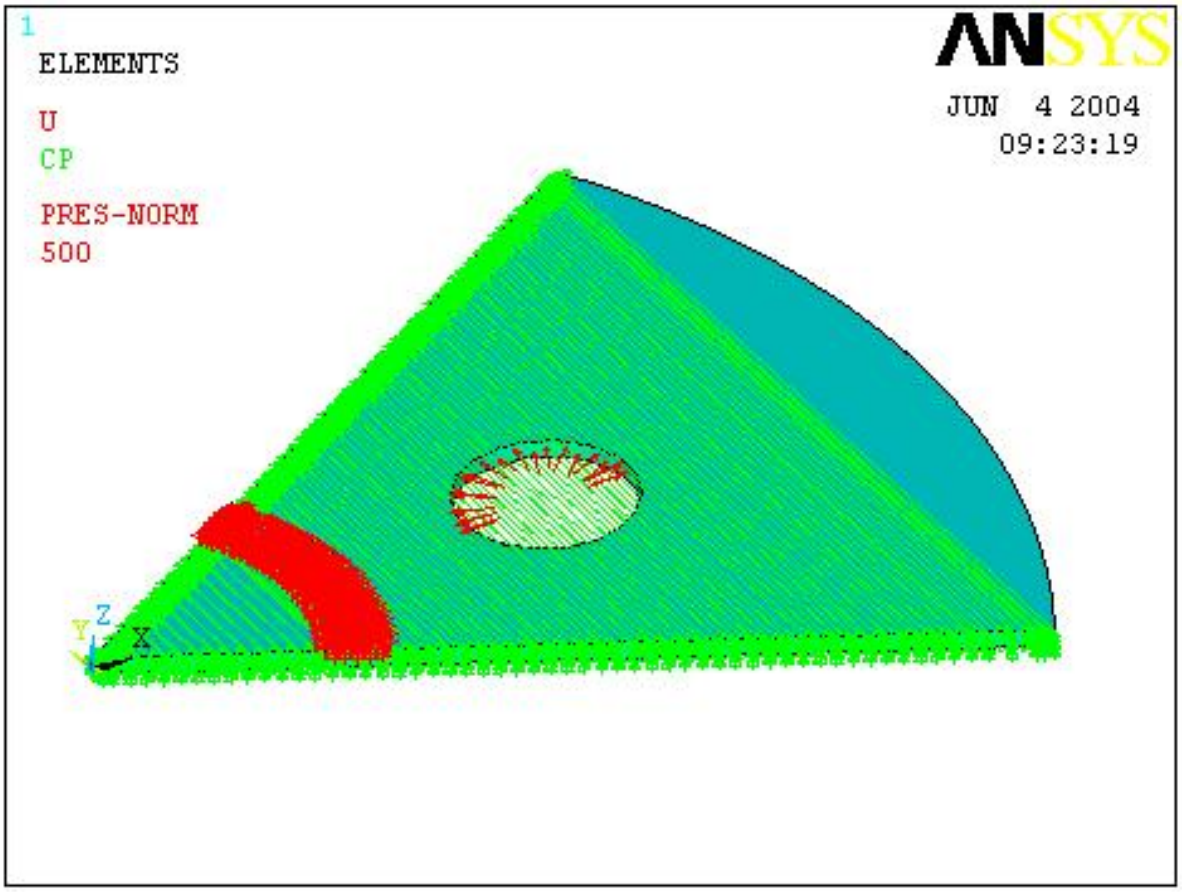
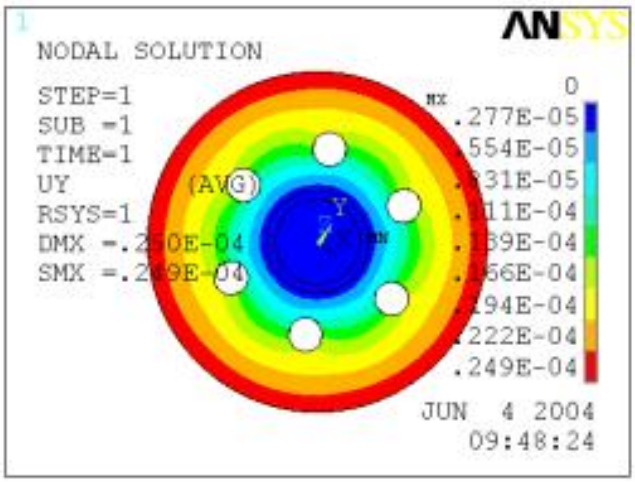
The boundary conditions look like this:



Note that this is not an approximation. A quick test on a full disk yields identical results!



You can download and use the macro of the above example (bvss.mac) as a guide in setting up your own problems! So start tossing around words like “cyclo-symmetric

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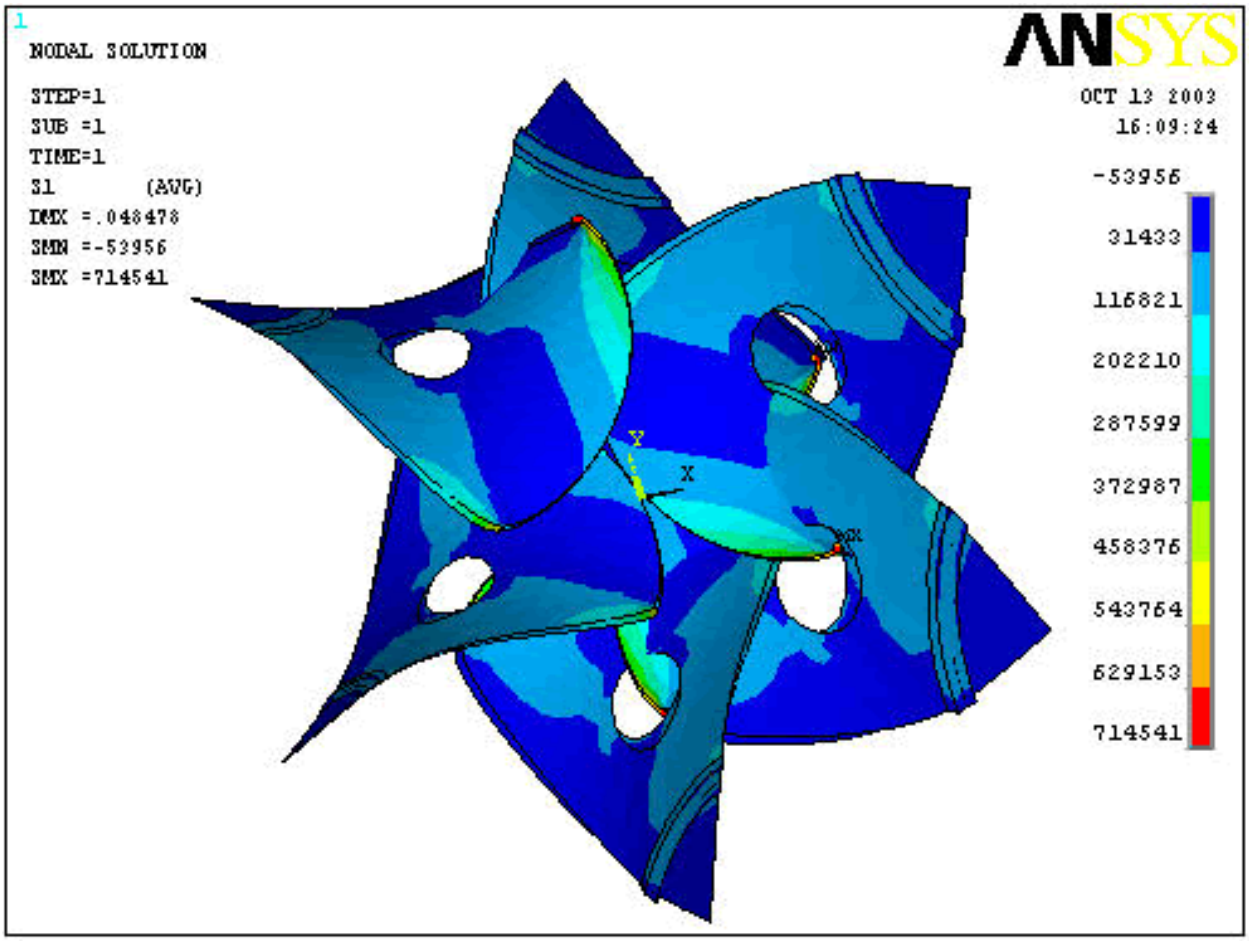
boundary conditions" to scare off anyone hassling you on schedule.

Often people use the term cyclo-symmetric to mean "modal cyclo-symmetric" which allows a modal analysis of a wedge sector to calculate modes for a full disk. Below are some resources for this special application of cyclo-symmetry.

- Modal Cyclic Symmetry and You, Version 6.0 (from *The Focus*, May 16, 2002)
- PADT Course #203, *Dynamics*
- Sheldon's ANSYS Tips & Tricks: Cyclic Symmetry at 6.0
- Cyclic Symmetry Analysis (from the 2002 ANSYS Conference)



What *not* to do: Forgot to merge nodes between sectors after copying. Escher meets ANSYS.

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2004 International ANSYS Conference

by Eric Miller, PADT

Venturing east of the Rockies is always tricky for us desert dwellers. The abundant vegetation and strange moisture in the air can confuse and distract even the most experienced traveler. Fortunately, all of the events at this year's ANSYS Conference were held at the Pittsburgh Hilton, a self-contained marble-floored island where all of the events and entertainment were held. When we did need to venture out for food, we only had to walk a few blocks through downtown, an area with even less green than my front yard. This year's conference was an enjoyable and informative trip that we wanted to share with other users before it fades from memory.

This was my third conference and one of the more significant because it focused on the emergence of the Workbench technologies from "something that is coming" to a usable tool that is "here." In the training held before the conference and during "short topic" lectures during the three-day event, developers from ANSYS exposed and discussed many aspects of the new technology. The hot topic in the lobby and at meals was how various people are finding the new technologies and what they have done with it. This was very rewarding to the programmers scattered around who have been working on these tools for almost five years now.

The biggest announcement of the week focused on solver technology: ANSYS and SGI worked together to successfully solve a 111 million degree of freedom problem! They had one of SGI's parallel machines in the ANSYS booth crunching away using the Distributed PCG solver. I talked with some of the programmers who worked on it, and they agreed that the problem was bigger than most people will run, but they did it to prove to themselves that all aspects of the program have been modified to handle large entity numbers as well as 64-bit memory addresses. Another thing that came out of this project was the need to make the rest of ANSYS, not just the solver, parallel. Several projects are underway right now to expand the technology to matrix assembly, meshing, and eventually post-processing.

Tuesday night was the highlight for me. A bunch of people who use the XANSYS

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mailing list got together for dinner and some embarrassingly geeky conversation. We almost made it through the entire meal but near the end, someone broke out a pen and started scribbling APDL code on the place mats. Fun, but sad.

The consensus view on the papers was that they were a little light on the technical side, but that many were very informative and useful. As usual, the bio-med folks always had some cool stuff that showed off how adaptable ANSYS was to different applications. My favorite was an analysis that replicated the way the bones actually increase their stiffness and density under load, using some clever APDL programming and an exemplary approach to solving the problem. Even though this was a small sampling, it showed the huge variety of people doing so many different things with these powerful tools.

Everyone seemed to agree that one of the more popular short topics was on Workbench Customization. The developers of the customization toolbox showed off some of the things they have been working on, and there was a good discussion on future steps. Similar seminars on Contact, CFX, and ICEM CFD tools were also well-attended. All the people I spoke with found them very informative.

Technically, this was a good conference and everyone appeared to get connected with others who were doing similar work. From a social standpoint it was also a success. It is nice to be surrounded by people who think, talk, and act the same, even if the businessmen in the elevators looked at us funny. We hope to see more of you there in two years!

For additional information on the highlights of the conference, please see the ANSYS web site.

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About *The Focus*

The Focus is a periodic electronic publication published by PADT, aimed at the general ANSYS user. The goal of the feature articles is to inform users of the capabilities ANSYS offers and to provide useful tips and hints on using these products more effectively. *The Focus* may be freely redistributed in its entirety. For administrative questions, please contact Rod Scholl at PADT.

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