The Focus

A Publication for ANSYS Users

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Using the DPCG Solver

by Carlos Shultz, PADT

Is the PCG solver not fast enough for you? Is your solution running too slowly because it is running out of RAM? Are your models too big to run on your machine? The DPCG solver provided with ANSYS 8.1 may be the answer to all your problems. Well, not all your problems, just the ANSYS PCG problems.

The following is a step-by-step guide to setting up the DPCG solver on Windows machines and some benchmark results. CompNameD, CompNameR, and CompNameB are the machines used for the examples and results.

Set-up DPCG

1. Install ANSYS 8.1 on the C Drive (you can omit this step on the machines that will only be running distributed jobs and not launching ANSYS)
2. Install MPICH on the C Drive by running the setup.exe on the ANSYS installation disk under the MPICH directory, install on the same drive letter for all machines that you plan to run DPCG
3. Add "C:\Program Files\MPICH\mpd\bin" to the Path environment variable on each machine
4. Test your setup using mpitestmpich.exe
   a. Move mpitestmpich.exe from "C:\Program Files\Ansys Inc\v81\ANSYS\bin\intel" to your working directory
   b. Create a host.list file (a text file with one machine name per line, put the launching machine first on the list)
   c. In a DOS command prompt window, type "Mpirun -np 2 -machinefile host.list mpitestmpich.exe", set the number after –np to the number of host machines, 2 for this example
   d. Results should be similar to Figure 1 below

Figure 1. Mpitestmpich.exe test that your machines communicate.

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5. Launch ANSYS with a Parallel Performance license option; select the type of MPI to use, MPICH is the free version included with ANSYS:
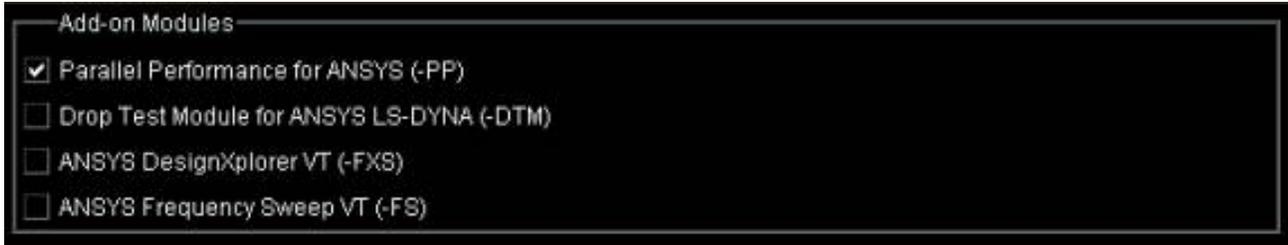
```
┌─Add-on Modules─────────────────────────────────────────┐
│ ☑ Parallel Performance for ANSYS (-PP)                  │
│ ☐ Drop Test Module for ANSYS LS-DYNA (-DTM)             │
│ ☐ ANSYS DesignXplorer VT (-FXS)                         │
│ ☐ ANSYS Frequency Sweep VT (-FS)                        │
└────────────────────────────────────────────────────────┘
```

Figure 2. Select –pp option from the launch tab of the launcher.

```
┌─Distributed Processing──────────────────────────────────────────────────────────┐
│ ○ None                                                                           │
│ ● Distributed Solvers (Requires that 'Parallel Performance for ANSYS' add-on module be selected on Launch tab) │
│ MPI Type: [MPICH          ▼]                                                      │
└──────────────────────────────────────────────────────────────────────────────────┘
```
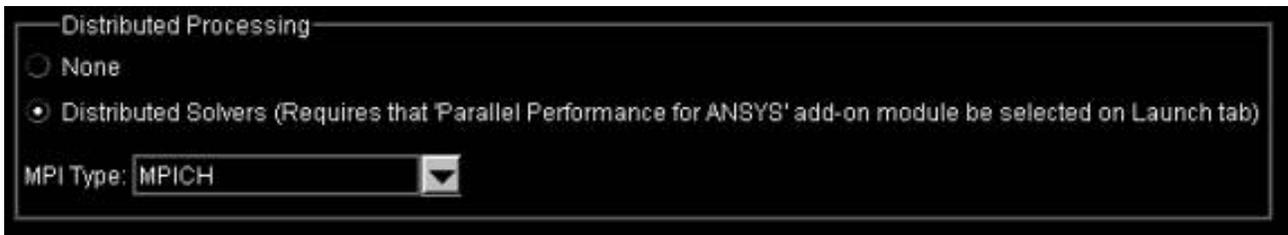
Figure 3. Select MPICH from the customization tab of the launcher.

6. Launch from a directory that is available on all of the machines you will be using. In other words, launch from "E:\ansys\benchmark\test" only if the same identical directory is available, otherwise you will get a fatal ANSYS crash with a cryptic I/O error.

7. If you are using macros, add APDL similar to the following commands to create all of the necessary text files, otherwise use the corresponding GUI picks,

The code examples below are from a run on 2 machines, CompNameR (dual proc) and CompNameD, using the script option, and running 2 cpu domains on CompNameR and 1 cpu domain on CompNameD.

```
EQSLV,DPCG,1e-8
DSOPT,SCRIPT,AUTO
DSPROC,3
```

These files are absolutely necessary and ANSYS crashes fatally without them. Make sure that the machine launching the job is listed first or ANSYS crashes fatally.

```
*CREATE,host,list !include host once per cpu domain
CompNameR
CompNameR
CompNameD
*END
```

```
*CREATE,ansdpcgmpich,bat
mpirun -np 3 -machinefile host.list "C:\Program Files\Ansys
Inc\v81\ANSYS\bin\intel\ansdpcgmpich.exe"
*END
```

The test machines run without the following files (all these files are mentioned in the help guides). This may be due to using a standard install on the C Drive.

```
*CREATE,hosts81,ans
```

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```
CompNameD intel 0 1 2000 0 E:\test MPI 1 1
CompNameR intel 0 2 2000 0 E:\test MPI 1 1
*END

*CREATE,config81.dpcg
CompNameD 1 "C:\Program Files\ANSYS Inc\V81\ANSYS\bin\intel\ansdpcg.exe"
CompNameR 2 "C:\Program Files\ANSYS Inc\V81\ANSYS\bin\intel\ansdpcg.exe"
*END

*CREATE,configmpich81.dpcg
exe "C:\Program Files\Ansys Inc\v81\ANSYS\bin\intel\ansdpcgmpich.exe"
hosts
CompNameD 1
CompNameD 2
*END

*CREATE,ansdpcg,bat
mpirun -np 3 -machinefile host.list "C:\Program Files\ANSYS Inc\v81\ansys\bin\intel\ansdpcg.exe"
*END
```

8. You will observe the following if you look at the Task Manager during solution, Figure 4 shows the Ansys.exe during meshing/element formation. The host machine has to do an element formation prior to the domain decomposition and results output after solution.
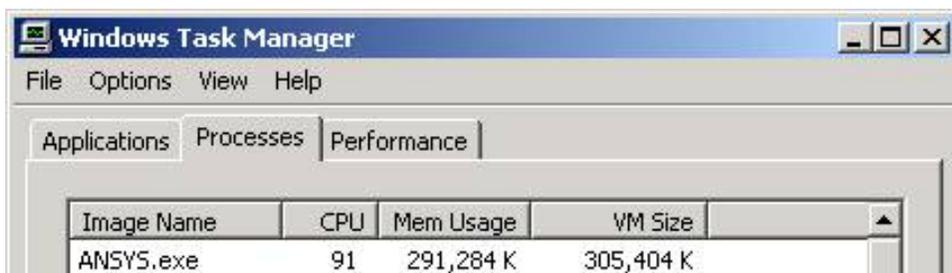

Figure 4. Resource usage shown during meshing/element formation.

9. Figure 5 shows the output window, you will need to enter your account name and password one time. They are stored in the registry (if you need to redo it, user regedit to find and delete the entries, HKEY_CURRENT_USER\Software\MPICH\Cache\Account and Password). You must have remote shell service login privileges on the machines you are using. Search windows help for Rshsetup.exe, Rshsvc.bat, Rshsvc.dll, and Rshsvc.exe to get the details of installing remote shell service. (For the cases run here, Windows XP worked without loading remote shell service, Windows 2000 needed it.)

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Figure 5. Enter the account name and password into the output window.

10. After mpich has launched, an ansdpcgmpich.exe will show up for each cpu domain requested, in the case shown in Figure 6, CompNameR was listed twice in the host.list file and has 2 domains solving. CompNameR is a dual cpu machine and can benefit from running mpich as a stand alone machine or with a network of machines. Note that the launching machine has an ANSYS.exe process running which does not always deallocate its memory.

Figure 6. Resource usage shown for a dual cpu machine running 2 domains.

11. For the same run as above, Figure 7 shows the resource usage for CompNameD, notice that the size of the memory used is roughly the same for each domain.

Figure 7. Resource usage shown for a remote machine running 1 domain.

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12. Figure 8 below shows the network traffic at the start of the run. Red indicates the sending and yellow indicates the receiving. It appears to do an initial check of the connections and then a sustained send to send the distributed domains.
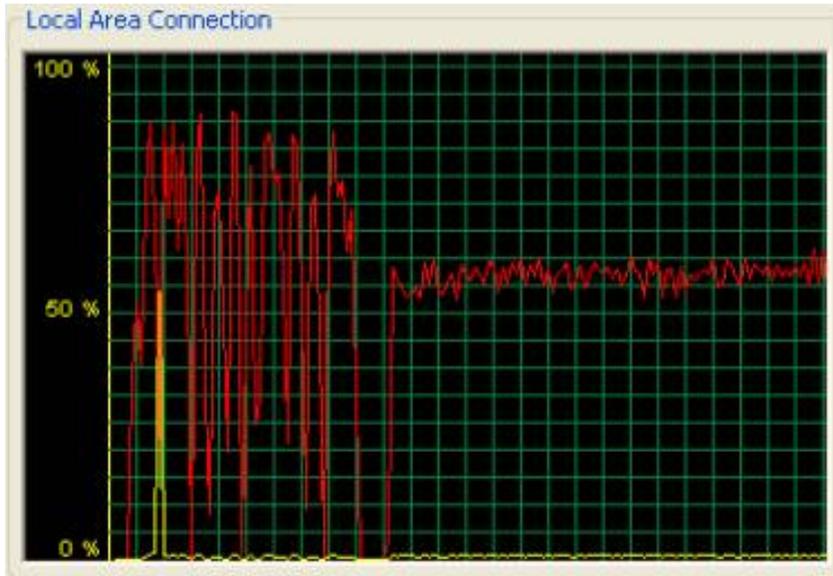

Figure 8. Initial network traffic.

Figure 9 below shows the intermediate network traffic. On the left is the end of the sustained sending of the problem. It is hard to tell specifically what is gong on as there is no output during DPCG solution, but the 2 sending peaks appear to be equilibrium iterations. Some of the traffic will also include the domain interface results being sent to each machine for reconciliation.
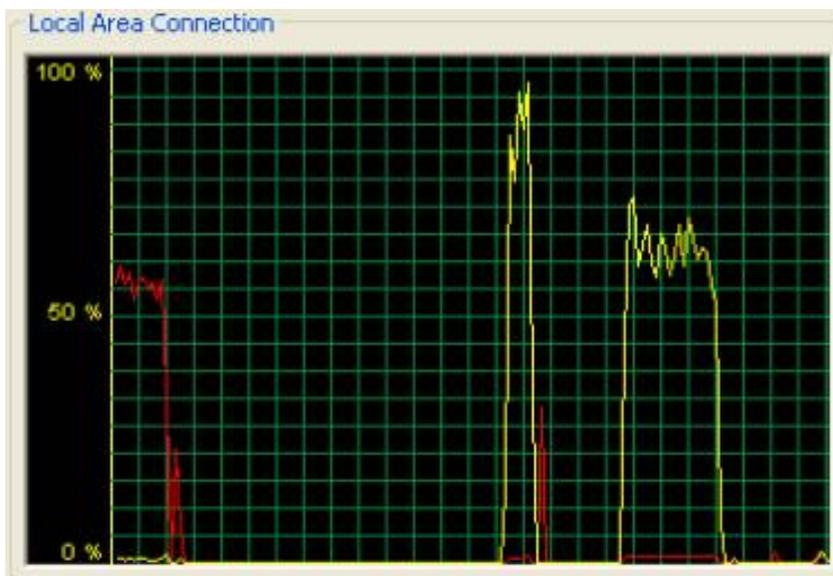

Figure 9. Intermediate network traffic.

Figure 10 below shows the final network traffic. The final peak appears to be the end command as communication stops and the distributed executables disappear from the remote machines.
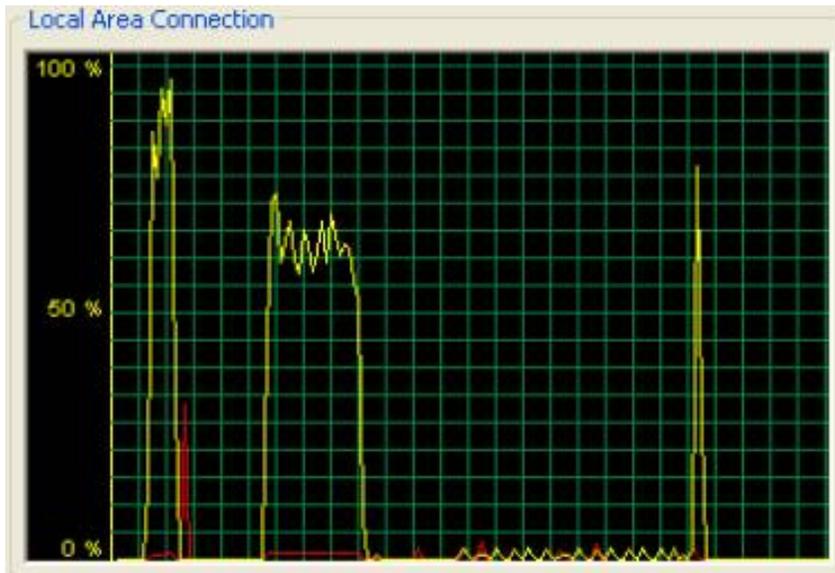
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Figure 10. Final network traffic.

Test Case Results

A simple structural model of SOLID95 elements was run for one iteration to 1e-8 accuracy unless noted differently. The domains used column shows how many domains were used; the first machine named also indicates where the job was launched.

The machines used for these results:

- D = CompNameD (1xP4 2.8GHz, 1Gb RAM)
- R = CompNameR (2xP3 1GHz, 1.5Gb RAM), nproc=2 unless noted
- B = CompNameB (1xP4 3.68GHz, 2Gb RAM)

1.04M DOF

The first model was run with 1.04e6 DOF with both the PCG and DPCG solvers. Table 1 below shows the results. CompNameD could not solve the model in-core and limped to a 2.07 hour solve time. Using 2 domains on CompNameR and CompNameD showed that the overhead of running DPCG can be significant and in the case of the single proc machine CompNameD devastating to solve time.

DOMAINS USED	PCG SOLVE WALL TIME	DPCG SOLVE WALL TIME	NOTES
R	0.265 hr		
R (1 proc)	0.297 hr		
D	2.07 hr		Ran out of RAM
B	0.065 hr		
R, R		0.422 hr	Overhead of DPCG shows up
D, D		4.39 hr	Don't try this at home kids!
R, R, D		0.259 hr	
D, R, R		0.225 hr	
B, D, R		0.146 hr	Fastest configuration

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B, D, R, R   0.173 hr

Table 1. Small PCG and DPCG runs.

1.99M DOF

Next, a bigger problem was solved. This model was too big to solve using PCG on the machines used. Launching from CompNameD is faster than launching from CompNameR unless the model goes out of core. Table 2 shows the results for this 1.99M DOF model.

DOMAINS USED	PCG SOLVE WALL TIME	DPCG SOLVE WALL TIME	NOTES
R	Cannot solve		
D	Cannot solve		
B	Cannot solve		
B, D, R		0.297 hr	Fastest configuration
D, R, R		0.576 hr	
B, D, R, R		0.381 hr	

Table 2. Medium DPCG runs.

3M+ DOF

Next, the accuracy was relaxed to see how big of a problem could be solved using DPCG. The solve times became impractically long before it failed to solve a model. Table 3 shows the largest models run.

TOTAL MEMORY USED	DPCG SOLVE WALL TIME (0.1 accuracy) R, R, D	PCG SOLVE WALL TIME (0.1 accuracy) B, D, R
3.05M DOF 3,246 Mb	3.56 hr	0.616 hr
3.38M DOF 3,599 Mb	Not run	0.854 hr
3.73M DOF 3,973 Mb	6.71 hr	1.13 hr
4.19M DOF 4,364 Mb	Not run	1.55 hr
4.85M DOF 5,702 Mb	Not run	4.74 hr

Table 3. Large DPCG runs, about 1Gb per M DOF.

Conclusions for this Test Case

- DPCG solver is easy to set-up and works well.
- Solving incore makes the difference between a practical and impractical solve time. DPCG can bring models back to incore solution.
- If PCG remains incore, don't use DPCG since PCG will be faster.
- DPCG can solve bigger problems than PCG using the same hardware.
- As always, your real simulations may produce different results. Test your systems to verify the performance gains of using DPCG.

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Krull vs. Tron

by Rod Scholl, PADT

Ahh, the eternal debate rages on. In the realm of stuff to throw at someone, that comes back, there are only two agreed upon greats – that Krull guy, and of course, the reigning champion Tron.

As my literature teacher was so fond of, let us draw our conclusions, not based on the merits of each, but rather based on the obscure metaphors on which they are based.

It is common knowledge that Krull is an Aristotelian representation of the Solid45, 92, 95 series of elements. And the futuristic neon Frisbee king is a neoclassical metaphor for the modern Solid 185-187 series. Shall we compare?

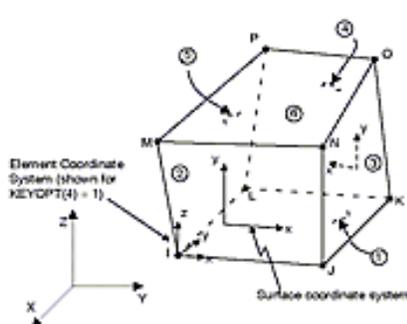## Krull, a.k.a. Solid45, Solid92, Solid95

No better combination exists of technological superiority in a robust and familiar "medieval common folk" element as are the 45, 92, and 95 elements.
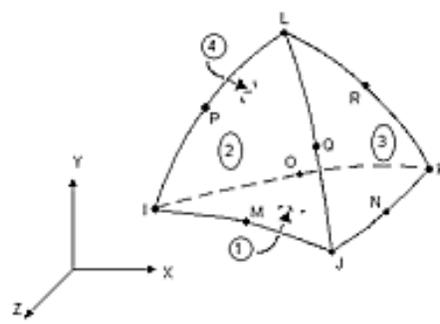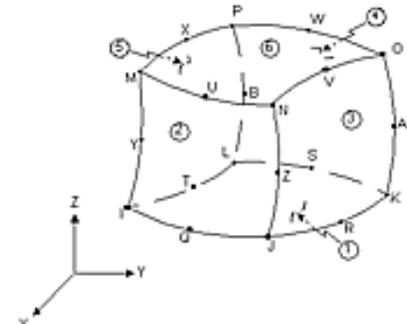
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Solid45

Solid92

Solid95

The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. It might not have a lot of the fancy lights, but engineers are rarely sold on pizzazz anyway. These elements are susceptible to shear and volumetric locking under some conditions.
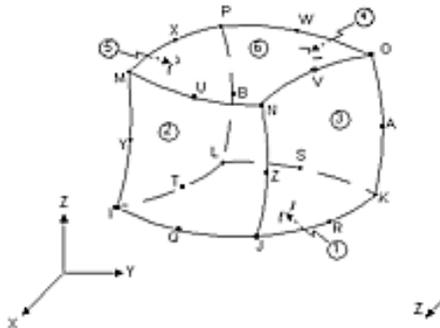
Tron, a.k.a. Solid185, Solid186, Solid187

On first glance there isn't much difference. These elements have the same plasticity, hyperelasticity, stress stiffening, creep, large deflection, and large strain capabilities.
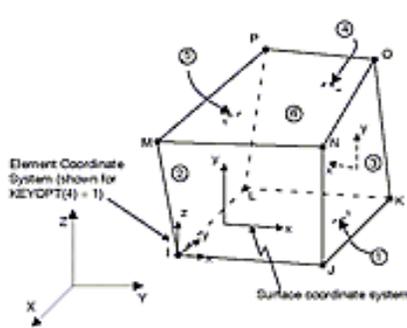
Solid185

Solid186
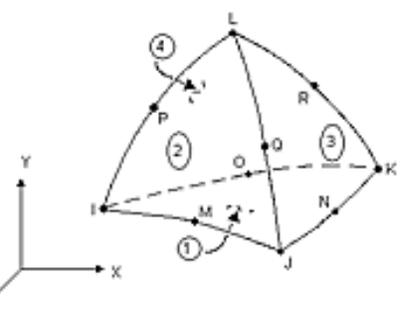
Solid187

But they also have several formulation types to address Shear and Volumetric Locking:

Element Technology	Lower-Order Elements	Higher-Order Elements	Shear Locking (Bending)	Nearly-Incompressible (Plasticity, Hyperelasticity)	Fully-Incompressible (Hyperelasticity)
B-Bar	Y	-	N	Y	N
Enhanced Strain	Y	-	Y	Y	N
Simplified Enhanced Strain	Y	-	Y	N	N
URI	Y	Y	Y	Y	N
Mixed U-P	Y	Y	N	Y	Y

The possible drawbacks:

- URI Formulation in lower-order elements can cause shear locking, and may require more elements to get accurate displacements and stress gradients.
- Enhanced strain formulation can be more computationally expensive.
- Mixed u-P formulation requires use of direct solvers.

Example

An example you say? Fine.

Remember that fated moment in Krull when the archaic star-shaped device gets stuck in the bad guy's chest? Our hero mentally strains and strains to telekenetically free the device and yet it won't budge?

This, my friends, is what we in the FEA world call "Volumetric locking". You see, Krull elements lack the Enhanced Strain Formulation that is desirable in bending dominated problems – not to mention that the 18X series Enhanced Strain Formulation prevents volumetric locking, which can occur in nearly incompressible cases.

Compared to the Solid45, 95, 92 elements, the 18X elements are almost identical in solution speed, and will yield nearly identical results for the majority of analyses. Also, future technology enhancements and formulations are being applied to these elements, while you can expect less enhancement to the Krull class of 45, 92, and 95.
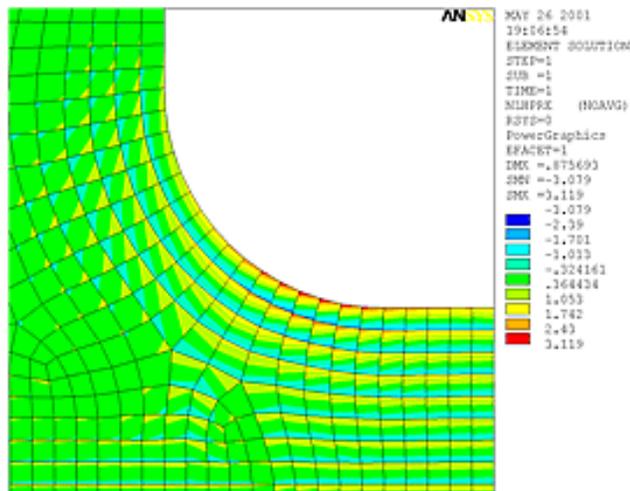
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Tron Is the Victor! [Solid185, Solid186, Solid187]

It seems you are best off using the Tron-esque Solid185-187 in every case, and just use the other elements when you're feeling nostalgic for the good old days. So go ahead, read about the 18X series. You know you want to.

Or, update your ANSYS skills with the [Advanced Structural Nonlinearities](#) class November 11-12 in Tempe, Arizona.

Honorable Mention

One more element that deserves an honorable mention is the Solid147 element. It is a P-formulation element that uses a shape function of up to an 8th order polynomial. Think of this one as like the Road Warrior's feral kid.

Note the razor-sharp boomerang. Kind of bad idea, right?

Victim loses fingers. (*The Focus* gets its first PG-13 rating, due to graphic violence and nudity. Okay, okay, no nudity.)

Vest, or hormone imbalance? These implanted yak follicles will soon be all the rage in Hollywood. Grrr, baby. Very, grrr.

More on the ANSYS 8.1 Upgrade

In case you were looking for one more reason to upgrade to 8.1, now ANSYS often reconginzes the full disk condition, and allows you oppurtunity to clear off some space and continue successfully.
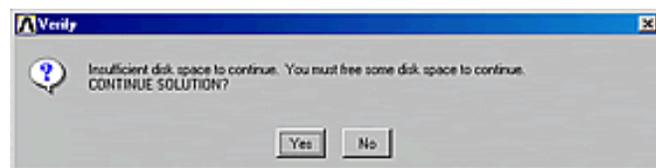
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Textbook response to the Random Read/Write I/O – Disk Full error.

There's gotta be a joke here about getting one's annual review and the adage about "…the hand that feeds you." In fact, I suggest that the picture above is a more appropriate and mature merit increase response.

And never show up to work like this. There is a dress code, after all.

Although this is permissable, it's just not encouraged.

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Are You an APDL Guru?

Shortly after last month's edition of the APDL guru hit the streets, the swami quickly received a number of correct responses to the first question. The swami knows a quick eye for errors marks the making of a true Guru, and the speed at which the correct answer was obtained made the swami proud indeed. Too simple, you say? Well, perhaps this month's puzzle shall require one to think a bit more outside of the proverbial box. Or maybe it's a helix?
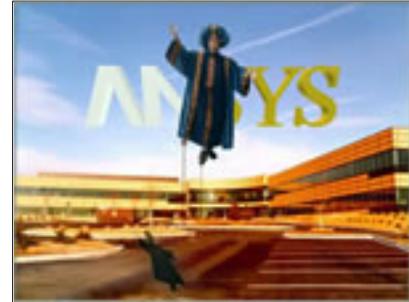
Before we reveal this month's puzzle, however, let's hand out some well-deserved awards. Ronald White sent in the first correct answer and, therefore, wins the prize as the Inaugural APDL Guru! (*golf clap, please*) As mentioned above, many others responded with the correct answer as well, so a round of kudos goes to all. See if your name is listed below.

The question from last month involved setting up a series of analyses to run sequentially overnight. The swami suggested the following code, but an error spoiled his fun.

```
fini
/cle
*do,i,1,3
parsav,scalar,foo,par
/cwd,./run_%i%
resume
/solu
solve
fini
/cle
parres,new,foo,par
*enddo
```

What is the smallest change that can be made to the above script to make it work? Well, it is all about directory structures. What goes up must come down, or more importantly, what goes down must come up. Upon the first time through the do loop, the code above navigates down into the subfolder run_1 and then runs the

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first simulation. However, we're still in the directory run_1 when the point of execution reaches the top of the do loop again. We went down, but we forgot to go up. One little line makes all things right again.

```
fini
/cle
*do,i,1,3
parsav,scalar,foo,par
/cwd,./run_%i%
resume
/solu
solve
fini
/cle
/cwd,.. ! ADD THIS LINE TO MAKE THINGS WORK
parres,new,foo,par
*enddo
```

Very easy indeed.

This Month's Puzzle

Well, this month the swami is feeling a bit like Dr. Seuss. Perhaps this month's puzzle will challenge a bit more.

I need a helical spring in ten,
Ten lines of APDL, and you will win.
Ten lines are all I have to spare,
How it is done, I do not care.

I need a helical spring in ten,
For inspiration think, "Remember when…"
Yes, the swami has heard it can be done.
Perhaps those who know won't spoil the fun.

I need a helical spring in ten,
One element in thickness should let it bend.
Those pesky NURBS have me all up in knots,
Perhaps inspiration can be found in beer and brats.

I need a helical spring in ten,

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Can you accomplish that within,
Ten lines of APDL or less?
If so, then surely you shall impress.

The goal of this months puzzle is to create an FEA model (shy of material properties, loads, and boundary conditions, but fully meshed) of a helical spring in the shortest amount of APDL code possible. The swami knows of an answer that takes about ten lines. One statement per line, and no sub macros can be called. Can you do better? Best answer wins!

Send your answers to apdl.guru@padtinc.com.

The following people submitted correct (or mostly correct) answers to last month's question: Ronald White, David Power, S. Prasad, Kim-Ravn Jensen, Jan Janssen, Ge Wang, John Zinn, and Girish, who for obvious reasons is a guru indeed. Way to go!

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