UNIVERSITY OF SASKATCHEWAN
DEPARTMENT OF MECHANICAL ENGINEERING
ME 450.3 FINITE ELEMENT ANALYSIS
FINAL EXAMINATION

Time: 3 hours
Open-book examination
Answer **four** questions only

December 2002
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Q1. Use *two* elements and consistent force vector to solve the beam loaded as shown.

a) Determine the slope at **B** (sketch the shape of the deflected beam) and the maximum deflection of the beam in section **BC**.

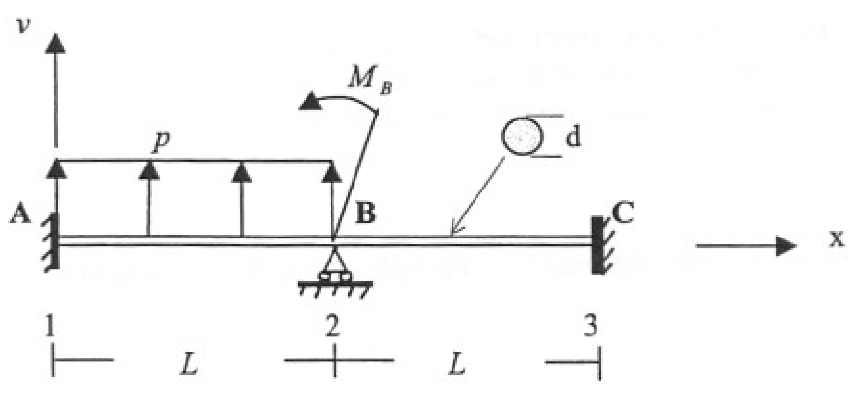
b) Calculate the reactions.

c) Determine the bending moment and the shear force for the elements. Plot **M** and **V** (use the ANSYS sign convention) for the whole beam.

d) Obtain the maximum bending stress and the maximum shear stress (average for the cross-section) using the data from the plots in (**c**).

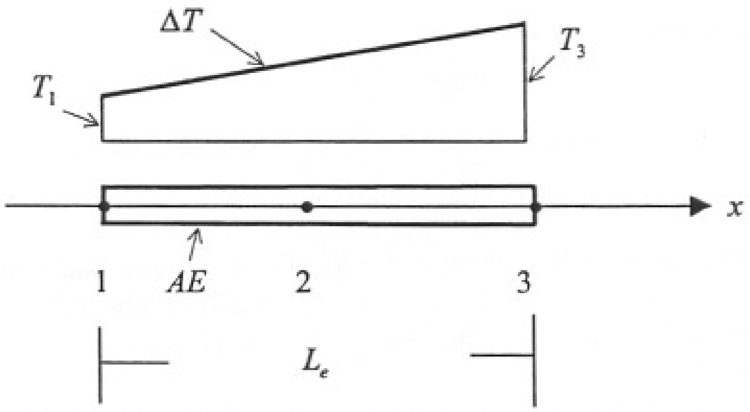
e) Choose one of the answers below, explain your choice.
- The results obtained in **a-c** are exact, no more elements are needed.
- To obtain results that will be more accurate need more elements *only* in section **AB**.
- To obtain results that will be more accurate need more elements *only* in section **BC**.
- More accurate results will be obtained only if more elements are used in sections **AB** and **BC**.

Given: $p = 1.5\, {}^{N}\!/_{mm}$, $M_B = 360Nm = 360{,}000Nmm$, $E = 2 \cdot 10^5\, MPa$
L=1200mm, d=24mm, $I = 16{,}286 mm^4$



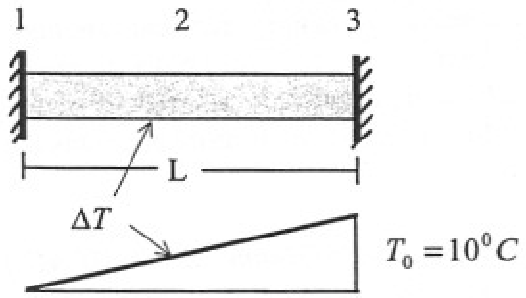
Q2. For the *quadratic* bar element (the *quadratic* shape functions) of *constant area* derive (in terms of A, E, α, T_1, and T_3) the vector of the 'thermal forces' $\mathbf{P}_t$ (three components) if ΔT varies *linearly*, (use $\Delta T(\xi)=T_1\frac{1-\xi}{2}+T_3\frac{1+\xi}{2}$ or $\Delta T(x)=T_1\frac{x_3-x}{L_e}+T_3\frac{x-x_1}{L_e}$).

- Apply the Gauss integration (use enough Gauss points to get exact results) to determine *at least one* component of $\mathbf{P}_t$.



- Use *one quadratic* bar element and the thermal forces as determined above to solve the problem shown (which is a part of the midterm exam question).

  Given: $E=2\cdot10^5\,MPa$, $A=200mm^2$, $\alpha=1.2\cdot10^{-5}\,{}^1\!/_C$, L=2000$mm$



Determine:

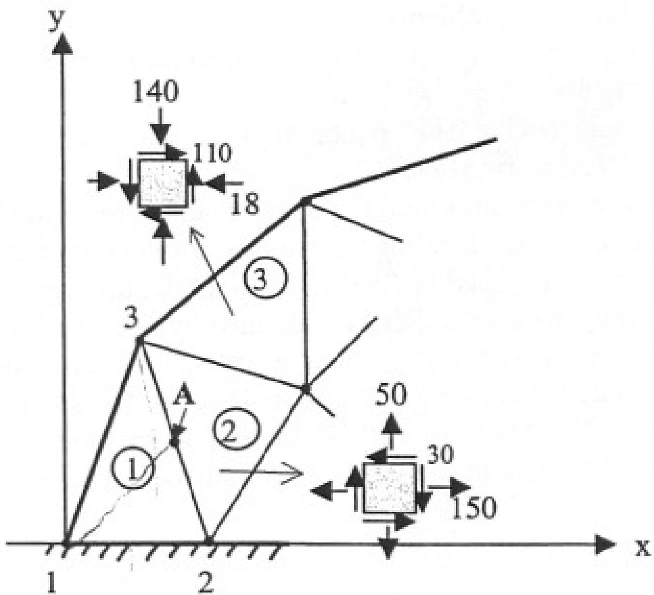
- The axial displacement at the bar center.
- The reaction forces at the supports.

Should this *one quadratic element* solution be:

- the same,
- better,
- worse

than the solution obtained with the help of *two linear elements*?

Q3.. A plane-stress problem is solved using linear triangular elements.



node	x(mm)	y(mm)
1	0	0
2	2	0
3	1	3

Nodes 1 and 2 in element (1) are fixed, and the displacement of node 3 is given by: $u_3 = -0.006mm$, $v_3 = 0.0012mm$.

a) Use the linear shape functions to determine the displacement of point **A**, which is in the middle of side 2-3.

b) Determine the strains in element (1).

c) Determine the stresses in element (1).

d) Determine the stresses at node 3 if the stresses in elements (2) and (3) are as shown (in *MPa*).

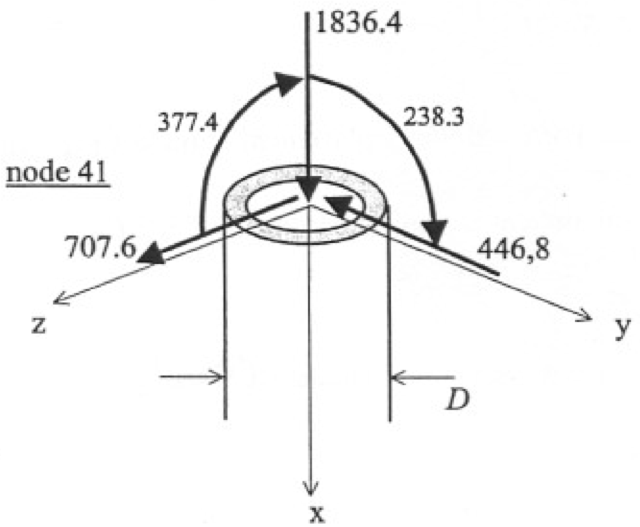
Given: E=200GPa, $\nu = 0.3$

Q4. This question is related to your lab work.

a) Due to double symmetry, in ***Lab#2*** (in *Q1* and *Q2*) the FEM model of only *a quarter* of the plates was used to solve the problems.
Can in ***Lab #4***, *Q3* only *a quarter* of the structure (and the motor) be used to solve the table problem? In particular:

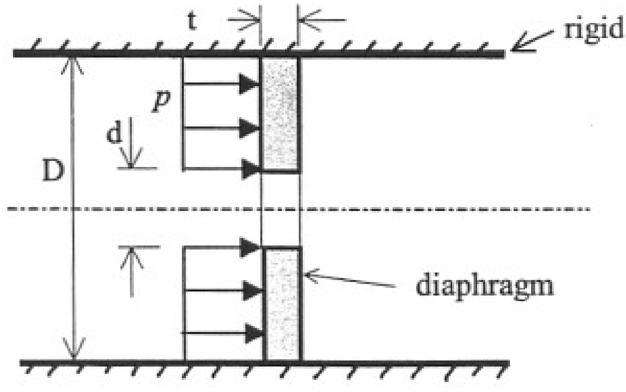
- How will the stress results (in the table and the legs) be affected?
- How will the vibration results be affected?

b) The nodal forces (and moments) in structural members modeled by **beam4** elements are calculated correctly, however, the bending stresses are correct only for rectangular cross-sections. Such elements were used in ***Lab#4***, *Q3* to model the legs made of hollow tubes (the cross-sectional properties of which were defined by *r,2,A,I,I,D,D*).
As read from the ***post*** file, the maximum compressive stress at the top of the leg (node 41) was -210*MPa*, while the nodal forces were: *Fx*= -1836.4*N*, *Fy*= 446.8*N*, *Fz*= -707.6*N*, *Mx*= 0, *My*= 377.4*Nm*, *Mz*= 238.3*Nm*. Using these forces (shown in the local CS below) calculate the correct value of the maximum compressive stress in the leg at node 41.



D=40*mm*
t=3*mm*
A=348,7 mm^2
I=60,066.5mm^4

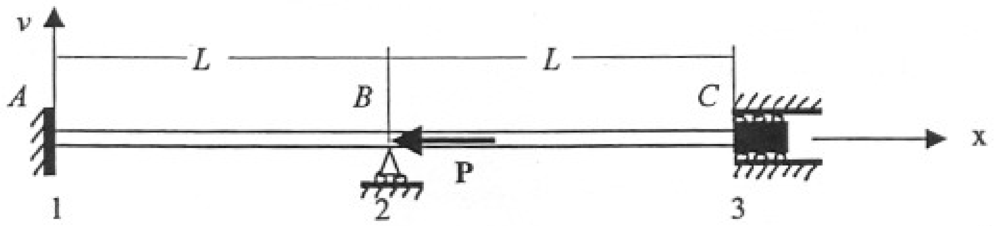
c) You are to analyze stresses in a plastic circular diaphragm fixed inside a rigid tube to control the flow of a fluid. For the fluid pressure *p*=0.25*MPa* acting as shown, and for the dimensions given write the ANSYS ***prep*** file that would solve the problem.



E=4*GPa*, $\nu = 0.4$
D=80*mm*, d=10*mm*
t=6*mm*

Q5. Axial force P=67,800*N* is to applied to the beam at point *B* as shown.
At *C* the beam is free to move in the x-direction, while $v_c = \theta_c = 0$.

a) Using <u>two</u> beam elements determine the safety factor against buckling.
Sketch the corresponding buckling mode.
Given: $E = 2 \cdot 10^5\, MPa$, L=1200*mm*, $I = 16{,}286 mm^4$



b) Choose one of the answers below, explain your choice.
- The result obtained is exact, no more elements are needed.
- To obtain results that will be more accurate need more elements *only* in section **AB**.
- To obtain results that will be more accurate need more elements *only* in section **BC**.
- A more accurate result will be obtained only if more elements are used in sections **AB** and **BC**.

THE END
Merry Christmas and Happy New Year!!!