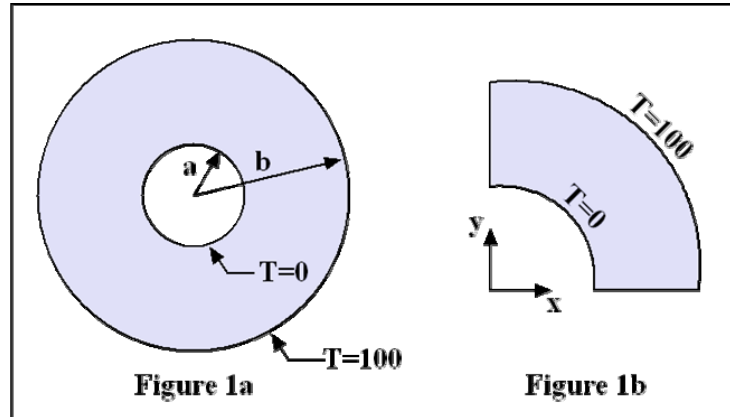


CE366/ME380 Finite Elements in Applied Mechanics I Fall 2007**FE Project 6: Heat Transfer****Due Date: 12/03/07****Steady State Heat Conduction in a Circular Annulus**

A circular annulus has an inner radius of $r = a$ and outer radius of $r = b$. The temperature on the inner radius is $T = 0$ and on the outer radius is $T = 100$ as shown in Figure 1a. The corresponding quarter symmetry finite element model is shown in Figure 1b.



The temperature $T(x,y)$ and heat fluxes $q_x(x,y)$ and $q_y(x,y)$ are functions of x and y . The exact solutions for the temperature $T(x,0)$ and heat flux $q_x(x,0)$ along the $y=0$ edge for $a \leq x \leq b$ are

$$T(x,0) = 100 \frac{\ln\left(\frac{x}{a}\right)}{\ln\left(\frac{b}{a}\right)} \quad q_x(x,0) = \frac{-100k}{\ln\left(\frac{b}{a}\right)} \left(\frac{1}{x}\right)$$

Perform the following two finite element analyses of this problem using four node quadrilateral elements:

- Case 1: ten elements along the horizontal and vertical edges
- Case 2: thirty elements along the horizontal and vertical edges

Use the following properties:

$$a = 1, b = 10, k = 0.1$$

Submit the following:

- Plot of $T(x,0)$ for $a \leq x \leq b$ based on exact solution, Case 1 and Case 2
- Plot of $q_x(x,0)$ for $a \leq x \leq b$ based on exact solution, Case 1 and Case 2
- Percent error in $T(x,0)$ for $a \leq x \leq b$ for Case 1 and Case 2
- Percent error in $q_x(x,0)$ for $a \leq x \leq b$ for Case 1 and Case 2
- Brief discussion of your results

The percent errors are defined as

$$\%error = 100 \frac{|T_{FE}(x, 0) - T_{exact}(x, 0)|}{100} \qquad \%error = 100 \frac{|q_x^{FE}(x, 0) - q_x^{exact}(x, 0)|}{|q_x^{exact}(x, 0)|}$$



ABAQUS/CAE Tutorial for FE Project 6

Module = Part

- Select “Create Part”, select “2D Planar-Deformable-Shell”

Create the annulus region from 2 arcs and 2 connecting lines

- Select “Create Arc: Center and 2 End Points” and enter the center (0,0), first end point (0,1) and second end point (1,0)
- Select “Create Arc: Center and 2 End Points” and enter the center (0,0), first end point (0,10) and second end point (10,0)
- Select “Create Lines: Connected” and add the horizontal line connecting the two arcs
- Select “Create Lines: Connected” and add the vertical line connecting the two arcs

 Create Arc: Center and 2 End Points	 Create Lines: Connected
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Module = Property

- Select “Create Material”, “Thermal” and “Conductivity” and input the value 0.1
- Select “Create Section” and use “Solid – Homogeneous” then “Continue”
- Select “Assign Section” and assign the section to the annulus region

Module = Assembly

- Select “Instance Part”, “Part-1”, “Independent (mesh on instance)” and “Continue”

Module = Step

- Select “Create Step” and “Heat Transfer” and “Continue”
- Select “Steady State” in the Edit Step window

Module = Load

We will prescribe the two temperature boundary conditions

- Select “Create Boundary Condition” and Types for Selected Step = Temperature, then “Continue”
- Select the inner arc of annulus and prescribe a temperature magnitude of 0
- Repeat the procedure and prescribe a temperature magnitude of 100 to the outer arc.

Module = Mesh

- Select “Seed Edge: by Number” and assign 10 (case 1) or 30 (case 2) elements along the horizontal and vertical edges
- Select “Assign Element Type”, change Family to “Heat Transfer” and use the default quad element DC2D4
- Select “Mesh Part Instance” and mesh the region

Module = Job

- Select “Create Job” and follow the usual procedure
- Select “Job Manager” and “Submit” the job

Module = Visualization

- Open the odb file

Create Path Plots

- Select “Tools – Path – Create” and “Node List - Continue”
- In the “Edit Node List Path” window, select “Add Before” then provide the Node List by picking nodes graphically along the horizontal edge from the inner to outer arcs
- Select “Create XY Data” and “Path” and “Continue”
- For “X Values”, select “X Distance”
- For “Y Values”, select “Field Output”
 - Select NT11 = Nodal temperature at nodes
 - Select “Save As” and the default name “XYData-1”
- Select “Field Output” again
 - Select HFL = Heat flux vector at integration points and Component = HFL1
 - Select “Save As” and the default name “XYData-2”
- Select “Report – XY”, select both XYData-1 and XYData-2 and OK
- XY data for path plots are written to the abaqus.rpt file.