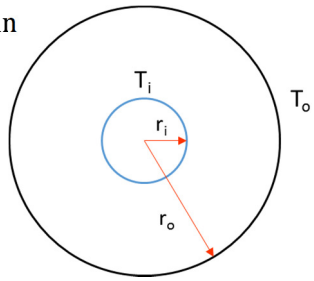
Indian Institute of Technology Mandi

Sub: **Applied FEM (**ME 505)

Final exam

Duration: 2.5 hour Marks: 70

1. The governing differential equation for the radial heat conduction through an annulus region is given below along with boundary conditions. Derive the weak form and find the solution

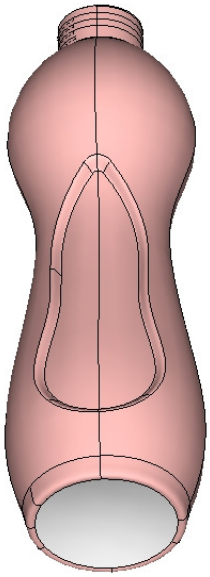


$$\frac{d^2T}{dr^2} + \frac{1}{r}\frac{dT}{dr} + \frac{q_0}{k} = 0$$

with boundary conditions: $T(r_i) = T_i$, $T(r_o) = T_0$. (**marks: 10**)

2. DYNAMIC ANALYSIS OF A WATER BOTTLE (total marks: 30)

A plastic bottle of about 300 mm length is given. Its properties are: Young's modulus: 3000 MPa, Poisson's ratio: 0.4, Density: 1380 kg/m^3. Create a folder and a ppt file in your name.



a) Mesh the bottle with an element size of 3 mm (**marks: 2**)

b) Perform a modal analysis of the bottle for the following two cases by extraction first 10 modes of vibration.

I. Free-free modal analysis (**marks: 5**)

II. Fixed-free modal analysis. Fixed the flat base of the plate from all DoF (**marks: 6**)

c) In slide no. 1 of the ppt, show the contour plot of displacement vector sum for the first flexible mode of vibration for both the cases. (**marks: 2+2 = 4**)

d) What is the frequency for the first flexible mode of vibration for both cases above? (**marks: 2+2 = 4**)

e) In which case the frequency of first flexible mode of vibration is higher and why? (**marks: 1+2 = 3**)

f) What is the frequency of first bending mode for above two cases? (**marks: 2+2 = 4**)

g) In slide 2, show the contour plot of displacement vector sum of the 10th mode of vibration for both the cases. Mention the frequency (**marks: 1+1 = 2**)

3. LINEAR STATIC ANALYSIS OF A PLATE WITH AND WITHOUT HOLE (total marks: 30)

a) Create two surfaces made of steel (Y = 2x10^{11} N/m^2, ρ = 7800 kg/m^3, Poisson's ratio = 0.3, thickness = 2 mm) for the following **two** cases: (**marks: 2+6 = 8**)

I. Create a 2D surface without any hole for mentions shown in the figure.

II. Create another component and then create two holes as shown in the figure.

b) Mesh the above two surfaces with 3 mm element size and applied boundary conditions as mentioned in the figure. (**marks: 3**)

c) Perform linear static analysis for above two surfaces and show the following:

A. Show the location of maximum von-Mises stresses in both the surface with contour plot in slide no. 3. (**marks: 6**)

B. In which case maximum stress induced is high and why? (**marks: 1+2 = 3**)

d) Make **ANY** design changes (case III) in case II geometry only such that maximum stresses induced near the holes is less than the maximum stress induced in the case I surface. Mention the changes made (slide 4) and compare the contour plot of stresses for case III and case I geometry (slide 5). (**marks: 10**)