Intro to Solid Mechanics

CIVENG W30/MECENG W85

Summer 2020

Final Exam

Time: 3 hours

Question	Grade
1	/20
2	/20
3	/25
4	/20
5	/20
Total	/105

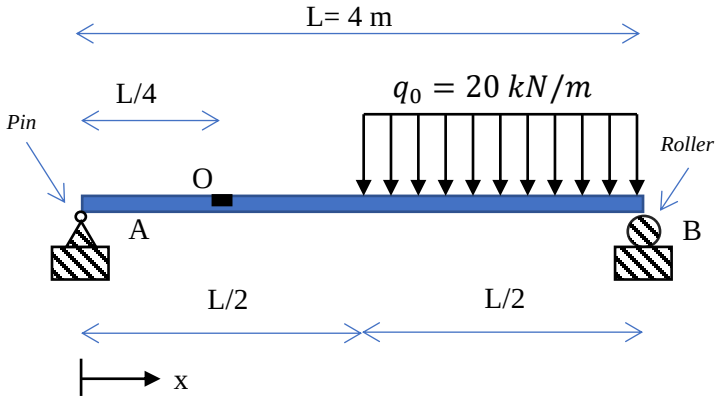
Name: _____

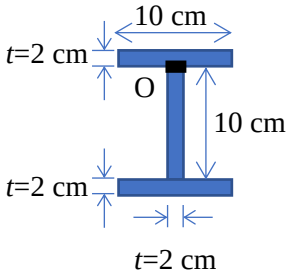
ID: _____

Please fill out and submit this page. If not submitted, there will be a **5 points** penalty.

Midterm #2 – Intro to Solid Mechanics - Summer 2020 Name: ID:

1- A beam is under a distributed load as illustrated in the image.
   a) Find the location and magnitude of the equivalent force of the distributed force and the reaction forces and moments at the supports. (5 points)
   b) Calculate the **shear forces** and **internal moment** of the beam as a function of x and plots their diagram. (10 points)
   c) Determine the location and value of maximum shear force and internal moment. (5 points)
   d) Considering the cross-section illustrated below, what is the shear stress at point O? (5 points)



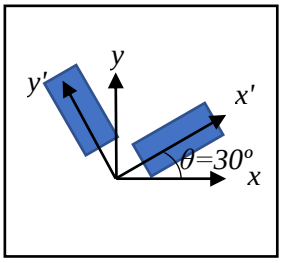


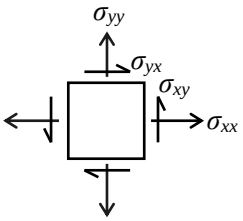
2- The state of stress for a thin plate is given as:

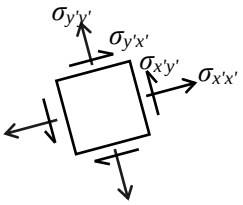
$$\sigma = \begin{bmatrix} 100 & 45 \\ 45 & 90 \end{bmatrix} MPa$$

in a plane with the normal vector along *x*. We have attached two stain gauges as shown on this plate.

a) Using **Mohr Circle** calculate the **strain** values that these two strain gauges would show. ($E = 100$ GPa, $\upsilon = 0.1$). Also, calculate the shear strain in this direction. (10 points)
b) Calculate the angle of the primary axes of stress and the corresponding stress values. (5 points)
c) Assuming $\sigma_Y = 150$ MPa, does this plate break? Use Von-mises criteria to explain your answer. (5 points)







3- We have attached a handle to a hollow cylindrical bar with a radius of R and thickness of t (t<<R). Three forces are applied to the handle as shown in the picture, resulting in **torsion**, **bending**, and **axial force** on the cylinder.

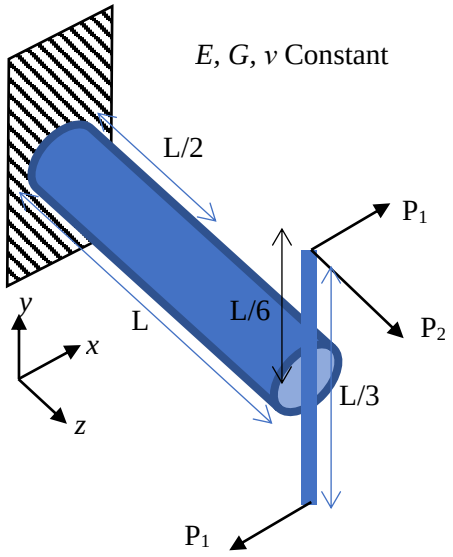
a) Assuming $P_1 = 0$ and $P_2=200$ kN, is there any location in the cross-section of the cylinder without any normal stress along z? If yes, at what value(s) of the y coordinate the normal stress along z would be zero? (5 points)

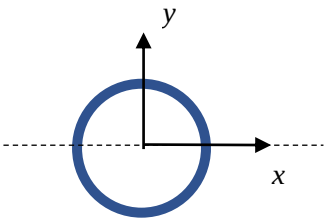
b) Assuming $P_1=100$ kN, $P_2=200$ kN, what is the maximum value for the shear stress in this cylinder, and at what location of the cross-section does it happen? (10 points)

c) Use the **eigenvalue method** to calculate the primary stress values at this location. (5 points)

d) Assuming $\tau_Y = 30\ MPa$, does this cylinder break under this set of forces? Use Tresca's criteria to explain your answer. (5 points)

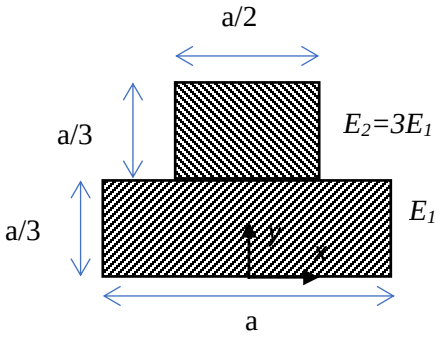
$L = 10$ m, $R = 0.5$ m, $t = 0.01$ m, $I_{xx} = \pi t R^3$.
Assume the handle is rigid and the attachment between the handle and the cylinder is perfect. The cylinder is fixed to the wall.





4- A beam is under a bending moment of M = 100 N.m. The cross-section of this beam is shown in the image. The upper section and the lower section of the beam are from different materials.

a) Find the neutral axis of bending. (5 points)
b) Find the effective bending stiffness. (5 points)
c) Calculate and plot the diagram of the normal strain and stress due to bending. (10 points)



a = 0.06 m

E_1 = 100 GPa

5- Consider the truss system shown in the image.

a) Calculate the support forces at A and B (5 points).

b) Calculate the axial force in beams 1,2, and 3. If buckling would occur in either beam 1 or beam 2, determine the maximum force P that we can apply before the structure collapses. Assume all the beams have pin-pin boundary conditions, and $E_1 = E_2$, $I_1 = I_2$. (10 points)

c) If we could choose the second moment of area of beam 1 as a factor of the second moment of area of beam 2 ($I_1 = \alpha I_2$), for what value of α, beam 1 and beam 2 would buckle with the same amount of force P. (5 points)