CIVE 310: Mechanics of Materials
Fall 2009, Prof. Ghassan Chehab

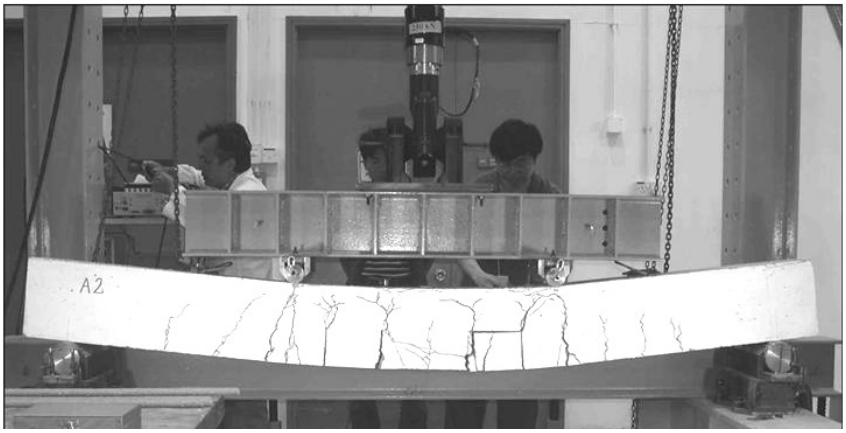
Exam 2
Closed Book and Notes
90 minutes

Name:_____

I. Provide an example structure of which the structural analysis and design can be assumed to be a (**10** pts):

a) Plane Stress problem:
b) Plane Strain problem:

II. An Unreinforced conrete beam is of the following dimensions: 20X25X240 cm. It is supported on a hinge and roller at its edges, as seen in Figure 1. A static 60- kN load is applied along the center of the stiff steel loadng plate, until cracking and ultimate failure occurs (as seen in Figure 2). Neglect self weight and weight of steel loading plate and assume $E_{concrete}$ is 25 GPa.



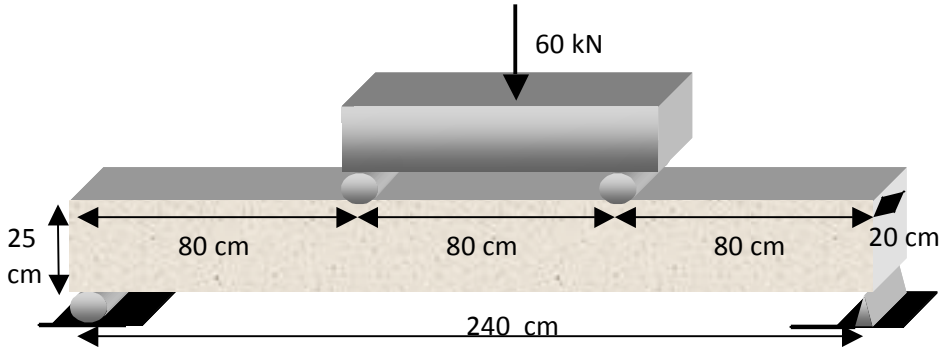
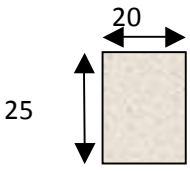


Figure 2

A. <u>Rectangular Crossection</u>



1. Calculate the moment of inertia of the rectangular cross-section in the direction of maximum bending. (**5** pts)

2. Draw the shear and moment diagrams and calculate the magnitude and location of the maximum positive and maximum negative bending moments. (**10** pts)

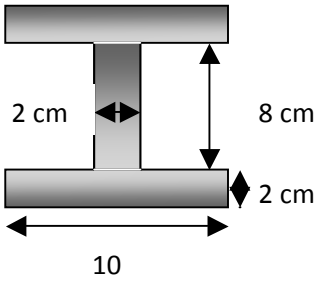
3. Calculate the magnitude and location of the maximum positive and negative axial stresses due to bending. (**10** pts)

4. What is the curvature of the beam due to bending? (**5** pts)

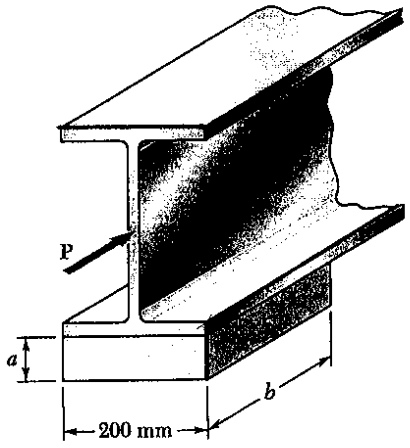
5. If the concrete strength in tension due to bending is 5 MPa, does the beam fail? If not, what is the factor of safety against failure in bending? (**5** pts)

B. I-Beam

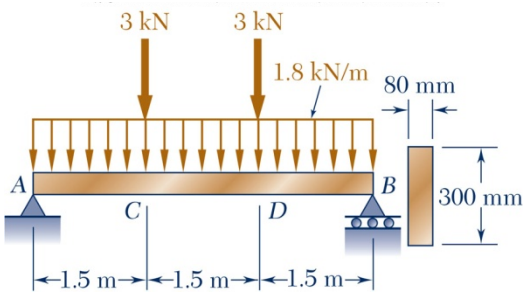
If the beam above is made of steel with a modulus of 250 GPa,: and a crossection shown below, what would the value of the maximum tensile stress be? (**15**)



III. An elastomer bearing (G=0.9 MPa) is used to support a bridge girder as shown in the figure, to provide flexibility during earthquakes. The beam must not displace more than 10mm when a 22-kN lateral load is applied as shown. Knowing that the maximum allowable shearing stress is 420 kPa, determine (a)the smallest allowable dimension **b**, (b) the smallest required thickness ***a***. (**15** pts)



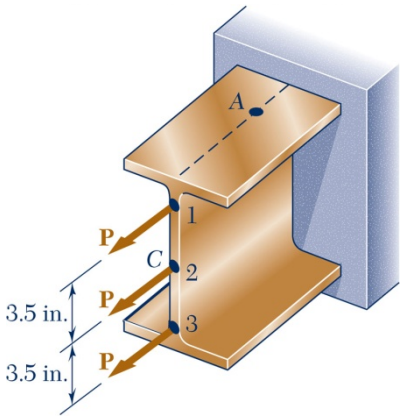
IV. For the beam and loading shown, determine the maximum normal stress due to bending on a transverse section at *C*. (**15** pts)



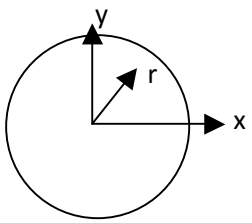
V. As many as three axial loads each of magnitude P=40 kN, can be applied to the end of a W200x31.3 steel beam. Determine the stress at point A, (a) for the loading shown, (b) if loads are applied at points 1 and 2 only. (**10** pts)

For W200x31.3:

Area=4000 mm^2; I =31.4x10^6 mm^4; depth, d, from top flange surface to bottom flange surface =210 mm. Assume 3.5"=90 mm



- **BONUS QUESTION:** Recalling that the polar moment of inertia for a circular cross-section about its center is $J = \frac{1}{2}\pi r^4$, show that the moment of inertia of the cross-section along the x and y axes about its center is $I_x = I_y = \frac{1}{4}\pi r^4$. (**10** pts)



Good Luck