Notre Dame University
Faculty of Engineering
Mechanical Engineering Department

Mechanics of Materials II (MEN 302)

Exam # 2
Spring 2015
May 30, 2015

Name : .... **Section :** A (MWF 10:00 – 11:00) □

ID : .... B (MWF 15:00 – 16:00) □

NOTES:

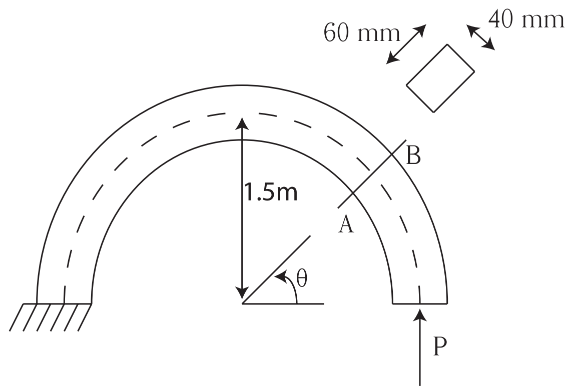
1. **ONLY one A4 paper (2 pages)** formula sheet is allowed.
2. This exam consists of 3 problems and 11 pages.
3. Cheating will not be tolerated.
4. The exam duration is 105 minutes.
5. All documents are allowed.

PROBLEMS	POINTS	GRADE
Problem 1	30	
Problem 2	35	
Problem 3	35	
FINAL GRADE		

Dr. Chady Ghnatios

Problem 1 [30 points]:

In a test of a semicircular aircraft fuselage beam, the beam is subjected to an end load P = 300 N that acts at the centroid of the beam cross section (As shown in the picture).



a) Determine the normal stress σ_θ that acts on the section AB as a function of radius r and angle θ, where, by figure 1, $0 < \theta < \pi$.
b) Determine the value of θ for which the stress σ_θ is maximum.
c) For the value of θ obtained in part (b), determine the maximum tensile and compressive stresses and their locations.
d) Determine the maximum tensile and compressive stresses acting on the section at $\theta = \frac{\pi}{2}$.
e) Compare the results obtained in parts c and d to those obtained using straight-beam theory.
f) Assuming the critical stress occurs when σ_θ is maximum; find the required σ_u for the material to prevent the beam from failure using Coulomb-Mohr theory.

Continue……………………

Continue……………………

Problem 2 [35 points]:

As final project for the mechanics of materials lab, the students are asked to build a bridge that will stand 800 N load on its center. The bridge a 5 mm above the ground and is supported as illustrated in figure 1.

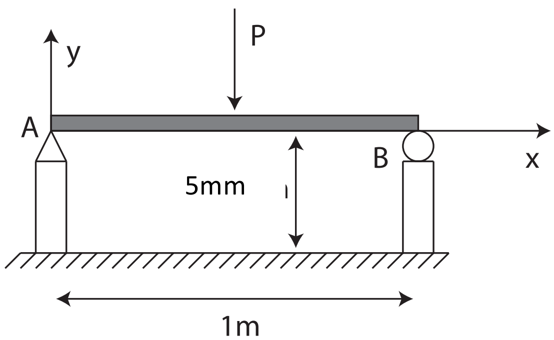


Figure 1: The bridge

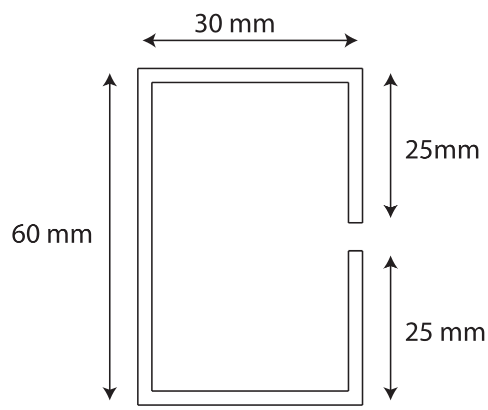


Figure 2: The cross section

A group of students built the bridge having the thin walled cross section of thickness t=1 mm illustrated in figure 2.

a) Find the moment of inertia I of the beam with respect to its axis of symmetry. Neglect all terms on t^2 and t^3. Find also the location of the shear center of the beam (bridge).

b) Supposing that the load is placed on the shear center of the beam, check if the bridge touches the ground and find the reactions on the supports. The elastic modulus of the material is E=10 GPa.

c) Draw the shear and moment diagram then using the maximum octahedral shear stress theory, find the minimum yielding stress of the material to avoid permanent deformation of the bridge.

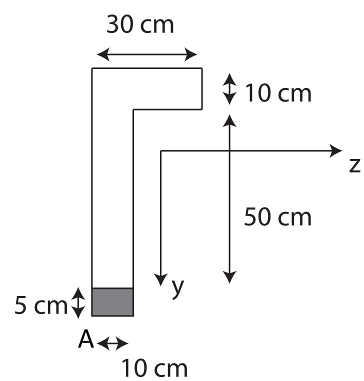
Continue……………………

Continue……………………

Continue……………………

Problem 3 [35 points]:

A composite beam is made of wood having a modulus of elasticity E=40 GPa and is reinforced by a steel part having a modulus of elasticity E= 200 GPa. The cross section of the beam is shown in the picture, the steel part in gray.



a) The beam is subjected to a bending moment around z-axis M_z. Homogenize the beam into a wooden one then find the maximum tension stresses in the wood and the steel function of the applied bending moment M_z.

b) The considered cross section is subjected to an oscillating bending moment between $M_{z\,min} = -5$ kN and $M_{z\,max} = 15$ kN. Using Soderberg failure criteria at point A, in the left side of the lower tip of the cross section, predict the life of the beam in number of cycles. Use a factor of safety of 2. The yielding stresses for the wood and the steel are given by: $\sigma_{Y\,steel} = 300$ MPa and $\sigma_{Y\,wood} = 100$ MPa, $\sigma_{u\,steel} = 500$ MPa and $\sigma_{u\,wood} = 200$ MPa. Use also K=1.

Continue……………………

Continue……………………