

Name: \_\_\_\_\_

Lab: Tu, W, Th, F

**ENES 220 – Mechanics of Materials**

**Spring 2000**

**May 24, 2000**

**FINAL EXAM**

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**Grading:**

Problem 1: \_\_\_\_\_ / 100

Problem 2: \_\_\_\_\_ / 100

Problem 3: \_\_\_\_\_ / 100

Problem 4: \_\_\_\_\_ / 100

Problem 5: \_\_\_\_\_ / 100

Problem 6: \_\_\_\_\_ / 100

Total: \_\_\_\_\_ / 600

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**Policies:**

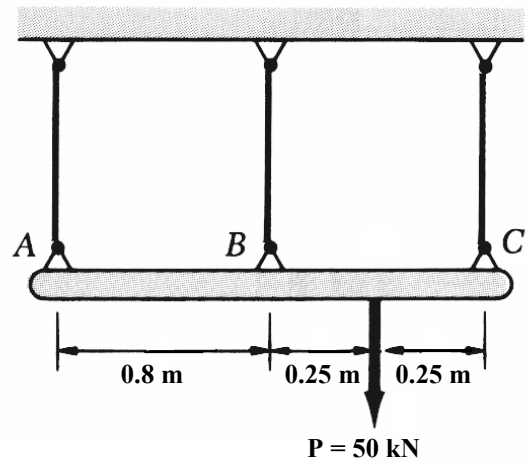
1. Write your name and circle your lab day on all sheets.
2. Use only the paper provided. Ask for additional sheets, if required.
3. Place only one problem on each sheet (front and back).
4. Draw a box around answers for numerical problems.
5. Include free body diagrams (FBDs) for all equilibrium problems.
6. Closed book; closed notes.
7. Show all work used to arrive at your answer in an organized, top-down fashion.

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**Problem #1:**

- (a) The rigid bar ABC is suspended from three steel wires as shown. Cables A, B, and C have a cross-sectional area of  $100 \text{ mm}^2$  and an elastic modulus  $E = 200(10^9) \text{ Pa}$ . Cables A and C each have a length of 1 m, but cable B was manufactured to a length of only 0.99 m by mistake. Write all equations for (1) equilibrium and (2) compatibility necessary to solve this problem. DO NOT SOLVE THE EQUATIONS.



- (b) Complete the following statements, using ONLY terms from the list below.

Poisson's ratio may have a value in the range from \_\_\_\_\_. Two items that describe the basic assumptions for writing equations in part (a) are \_\_\_\_\_ and \_\_\_\_\_.

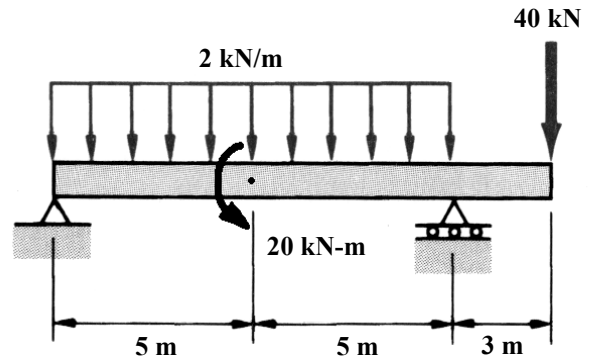
- |            |                      |                          |                  |
|------------|----------------------|--------------------------|------------------|
| -0.5 to 0  | heterogeneous        | anisotropic              | linear-elastic   |
| 0 to 0.5   | homogeneous          | ductile material         | plastic material |
| 0.6 to 1.0 | Von Mises' Principle | Mohr's Failure Criterion |                  |

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**Problem #2:**

- (a) Plot the shear and bending moment diagrams for the beam subjected to the loading shown below. Identify all critical points necessary to unambiguously define all points on the diagrams.



- (b) Complete the following statements, using ONLY terms from the list below.

For the V & M diagrams to be applicable, the material \_\_\_\_\_

and the cross section \_\_\_\_\_ .  $V = 0$  at the

free end(s) is equivalent to \_\_\_\_\_ .

does not have to be linear-elastic

must be linear-elastic

must be brittle

does not have to be uniform

must be uniform

must be ductile

the principle of minimum potential energy

$\Sigma F_x = 0$

$\Sigma F_y = 0$

must be subjected to bending about the major axis

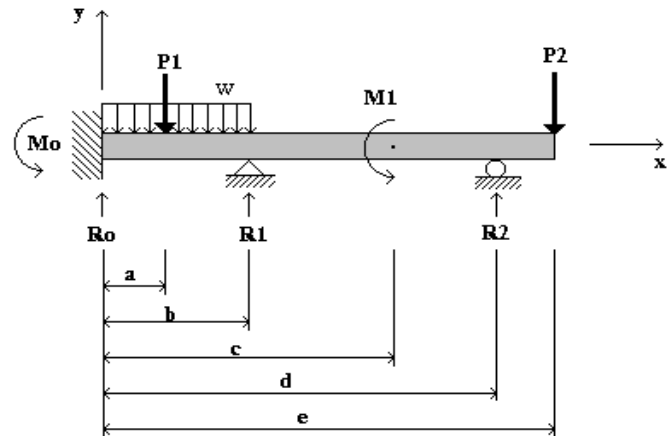
$\Sigma M_z = 0$

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**Problem #3:**

- (a) The beam shown below is subjected to several forces, moments, and support reactions along its length. (1) Write a single expression for moment for the domain  $0 < x < e$  (i.e. the entire beam) in terms of  $M_0$ ,  $R_0$ ,  $P_1$ ,  $w$ ,  $R_1$ ,  $M_1$ ,  $R_2$ ,  $P_2$ , and geometry. (2) Write a single deflection equation for  $0 < x < e$  in terms of  $M_0$ ,  $R_0$ ,  $P_1$ ,  $w$ ,  $R_1$ ,  $M_1$ ,  $R_2$ ,  $P_2$ , and geometry.



- (b) Complete the following statements, using ONLY terms from the list below.

Part (a) assumes that the beam has \_\_\_\_\_ and the \_\_\_\_\_ is  $\ll 1$ . The shear deformation is \_\_\_\_\_.

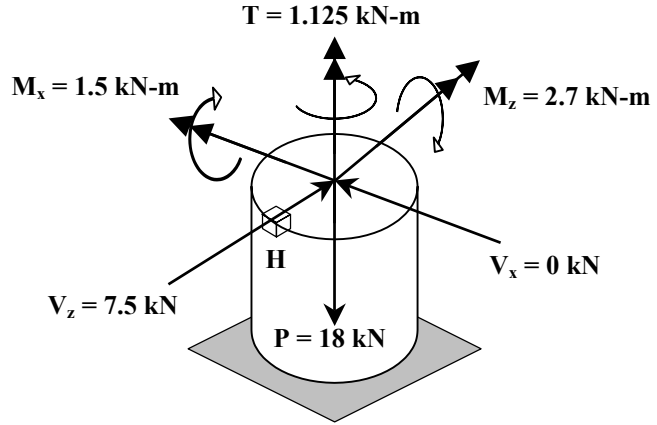
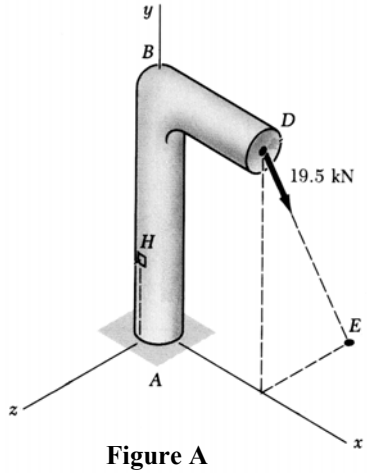
- |  |          |                         |                    |              |
|--|----------|-------------------------|--------------------|--------------|
| constant EI  | rotation | ignored                 | constant curvature | no thickness |
| about the same order of magnitude as bending deformation |          |                         |                    | deformation  |
| to be statically determinate                             |          | no flexural deformation |                    | curvature    |

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**Problem #4:**

(a) A 19.5 kN force is applied at point D to the cast iron post depicted in figure A. This force causes internal forces and moments on the bottom section, in the directions shown in figure B. The post has a uniform circular cross-section with a diameter of 60 mm. Calculate the stresses that act at point H. Place your answers in the table below. Also, illustrate the stresses due to each load and the combined stress state on cubes in the table. Assume  $E = 165 \text{ GPa}$  and  $G = 65 \text{ GPa}$  for cast iron. (Perform all calculations on another page.)



$$Q = \frac{2}{3}r^3$$

Loads	$V_x$	P	$V_z$	$M_x$	T	$M_z$	Combined stresses @ pt. H
Stresses @ pt. H due to:							
Stresses on 3-D cube							

(b) Complete the following statements, using ONLY terms from the list below.

At point H, the normal stress is in the \_\_\_\_\_ direction. A straight line on the cross-section \_\_\_\_\_ after deformation.

To obtain stresses, the material is assumed to be \_\_\_\_\_.

- |        |                  |           |                             |
|--------|------------------|-----------|-----------------------------|
| axial  | circumferential  | inelastic | hyper-elastic               |
| radial | is unpredictable | elastic   | becomes quadratic           |
| hoop   | remains straight | plastic   | is curved but not quadratic |

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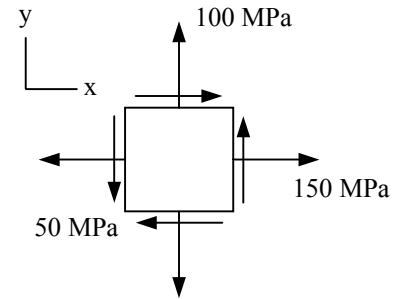
**Problem #4 (con't.):**

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**Problem #5:**

- (a) For the state of plane stress given on the element below, construct a Mohr's Circle. Use the circle to determine (1) the principal stresses, (2) the principal stress directions, (3) the maximum in-plane shear stress and corresponding normal stress, and (4) the shear stress direction. Show all quantities on properly oriented STRESS CUBE(S).



- (b) For a state of hydrostatic tension of 100 MPa (i.e.  $\sigma_1 = \sigma_2 = \sigma_3 = 100$  MPa), construct the Mohr's Circle(s) and calculate the absolute maximum shear stress.

- (c) Complete the following statements, using ONLY terms from the list below.

For an isotropic, linear-elastic material, the volumetric strain for a state of hydrostatic tension of 100 MPa is \_\_\_\_\_ the volumetric strain for a state of uniaxial tension of 300 MPa (i.e.  $\sigma_1 = 300$  MPa;  $\sigma_2 = \sigma_3 = 0$ ). The state of plane stress for  $\sigma_1 = -\sigma_2$  is known as pure \_\_\_\_\_. For a state of uniaxial tension, the failure stresses predicted by the maximum-shear-stress and maximum-distortion-energy theories are \_\_\_\_\_.

equal to	greater than	less than	identical	opposite
tension	compression	shear	different	changed

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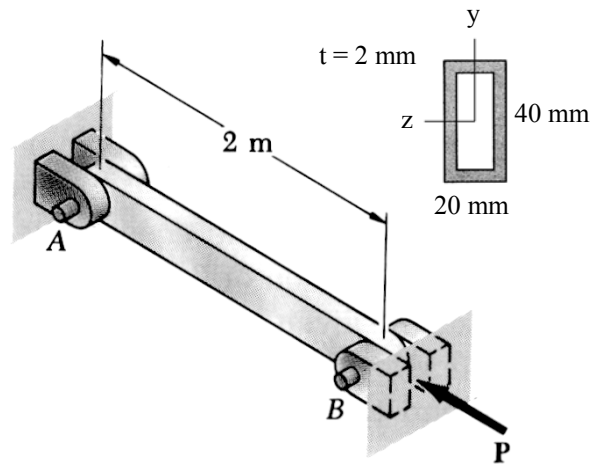


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**Problem #6:**

- (a) The aluminum tube AB has a hollow, rectangular cross section with a thickness of 2 mm, and is supported by pins and brackets at the ends. The constraints produce a pinned-pinned condition about the z-axis, and a fixed-fixed condition about the y-axis. Using  $E = 70 \text{ GPa}$  and  $\sigma_{ys} = 250 \text{ MPa}$ , find the allowable centric load  $P$  if a factor of safety of 2.5 is required.



- (b) Complete the following statements, using ONLY terms from the list below.

For the same support conditions, a column will always buckle around the axis where the moment of inertia is \_\_\_\_\_. Deformation due to buckling is primarily in a \_\_\_\_\_ direction to the column axis. The two modes of failure for a column, similar to the one shown, are buckling and \_\_\_\_\_.

largest	principal	rotational	fatigue
smallest	parallel	symmetrical	torsion
indeterminate	perpendicular	bending	yielding

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