Name: ______________________________

Lab: Tu, W, Th, F

ENES 220 – Mechanics of Materials

Spring 2000

May 24, 2000

FINAL EXAM

Grading:

Problem 1:	______	/ 100
Problem 2:	______	/ 100
Problem 3:	______	/ 100
Problem 4:	______	/ 100
Problem 5:	______	/ 100
Problem 6:	______	/ 100
Total:	______	/ 600

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. <u>Show all work used to arrive at your answer in an organized, top-down fashion</u>.

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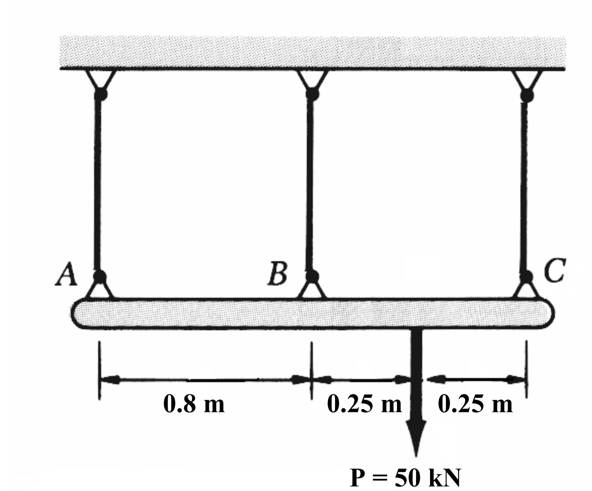
Problem #1:

(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 mm^2 and an elastic modulus $E = 200(10^9)$ 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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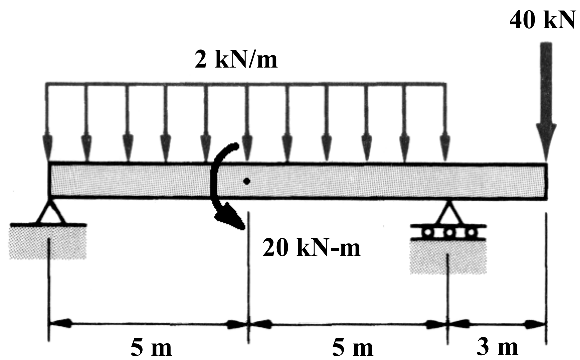
Problem #2:

(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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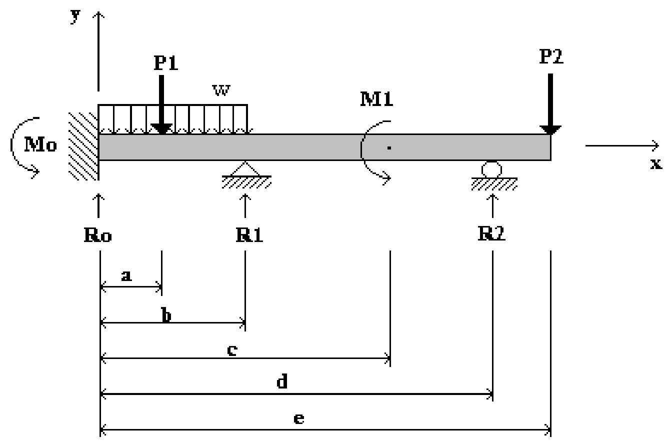
Problem #3:

(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 << 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 GPa and G = 65 GPa for cast iron. (Perform all calculations on another page.)

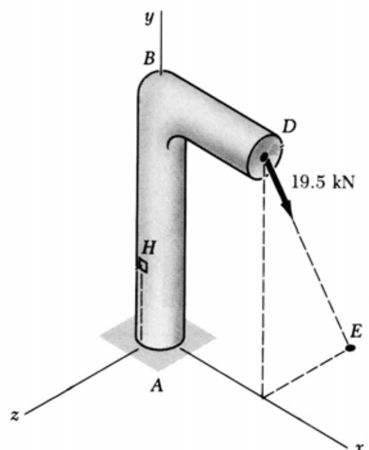

Figure A

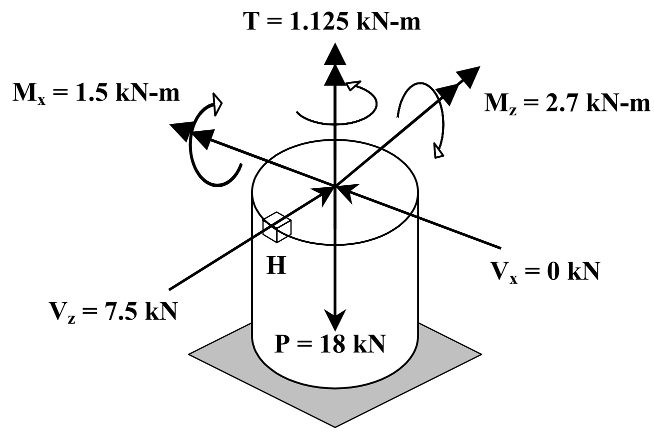

Figure B

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

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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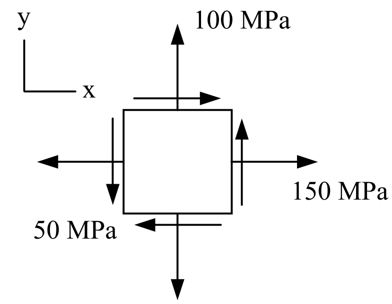
Problem #5:

(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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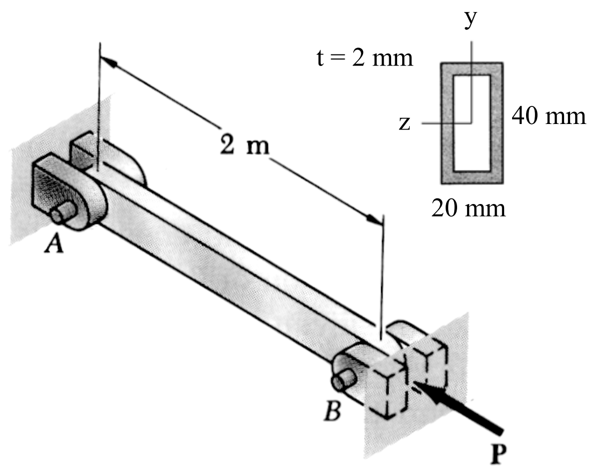
Problem #6:

(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 GPa and σ_{ys} = 250 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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