FORM A

ESM 2204 Fall 2005
MECHANICS OF DEFORMABLE BODIES
Final Exam

NAME
(print legibly)____
last first initial

PLEDGE (signature): On my honor I have neither given nor received unauthorized aid on this test.

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INSTRUCTIONS:
Closed book, closed notes, 8.5” x 11” formula (only) sheet.
- There are 11 questions on this exam - check for completeness.
- Please be sure to mark you Form letter on the op-scan form.
- Part I (54%) consists of 9 multiple-choice problems (each problem is worth equal credit).
- Part II (46%) consists of two work-out problems. Please complete all work in the space provided.

Turn in your results in the following order:
Exam questions (signed)
Formula sheet

CHECK FOR COMPLETENESS

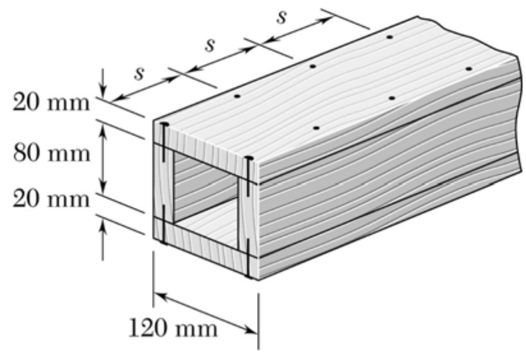
Answers:

Part I:
1) 1387 N
2) 3961 lb
3) (6wL + 5P)/16
4) 7330 psi
5) 5.13 ksi
6) 0.0754 mm
7) 186 N
8) 41.7 kN
9) 12.38 ksi

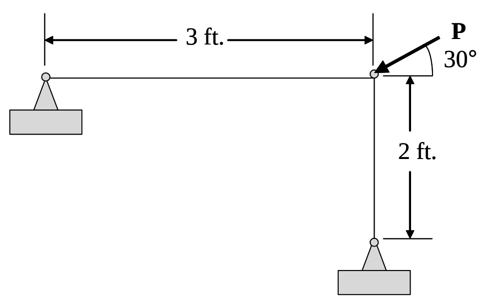
Part II:
1) $\delta_{@D} = 4\ a\ \Delta T\ L / 3$
2) h = 14.55 in

PART I: MULTIPLE CHOICE PROBLEMS (6 Points each)

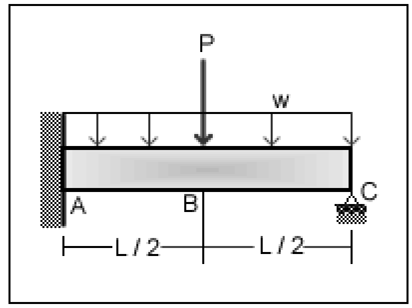
1. A square box beam is made of two 20X80-mm planks and 20X120-mm planks nailed together as shown. Knowing that the spacing between the nails is s = 50 mm and that the allowable shearing force in each nail is 300N, the largest allowable vertical shear in the beam is most nearly
   (a) 147 N
   (b) 694 N
   (c) 1387 N
   (d) 2770 N
   (e) 5540 N



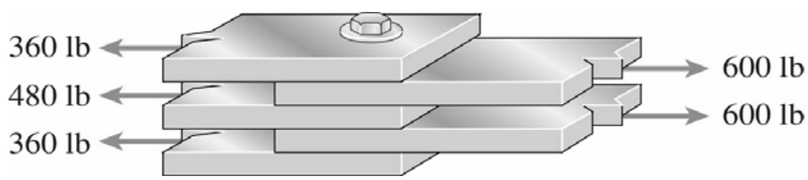
2. In the structure shown, each member has a diameter of 0.75 in and is made from steel (E = 29x10^6 psi). If a factor of safety of 2.0 against buckling is required, the maximum allowable load P is most nearly
   (a) 7720 lb
   (b) 3430 lb
   (c) 3960 lb
   (d) 15400 lb
   (e) 6860 lb



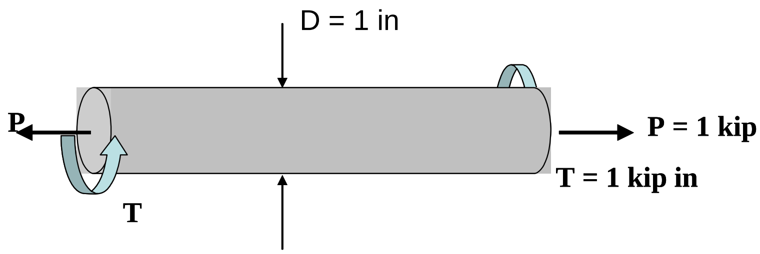
3. For the beam and loading condition shown, the reaction at support C is most nearly
   (a) (6wL + 5P)/16
   (b) (5wL + 6P)/16
   (c) (6wL + 5P)/8
   (d) (5wL + 6P)/8
   (e) (6wL + 5P)/4



4. The connection shown below consists of five steel plates, each 3/16 in. thick, joined by a single ¼ in. diameter bolt. The total load transferred between the plates is 1200 lb, distributed among the plates as shown. The largest shearing stress in the bolt is most nearly
   (a) 24400 psi
   (b) 9780 psi
   (c) 12200 psi
   (d) 7330 psi
   (e) 3670 psi

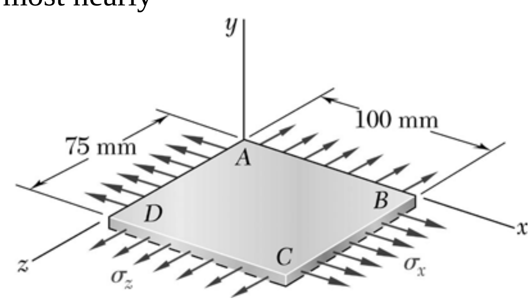


5. A cylindrical bar is subjected to the applied torque and axial load shown. The maximum shear stress in the bar is most nearly



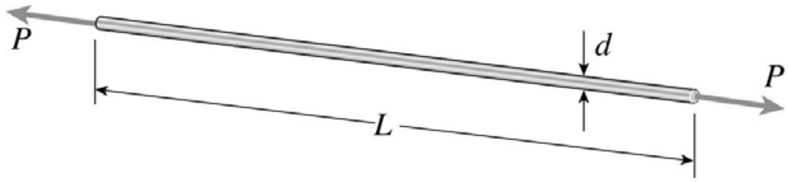
(a) 5.13 ksi
(b) 5.09 ksi
(c) 1.27 ksi
(d) 0.64 ksi
(e) 5.77 ksi

6. A fabric used in air-inflated structures is subjected to a biaxial loading that results in normal stresses σ_x = 120 MPa and σ_z = 160 MPa. Knowing that the properties of the fabric can be approximated as E = 87 GPa and ν = 0.34, the change in length of side AB is most nearly

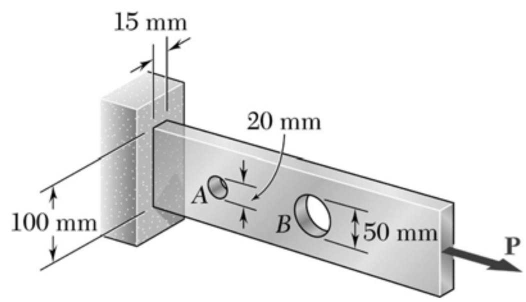


(a) 0.1503 mm
(b) 0.200 mm
(c) 0.1034 mm
(d) 0.1379 mm
(e) 0.0754 mm

7. An aluminum wire having a diameter d = 2 mm and length L = 3.8 m is subjected to a tensile load P (see figure). The aluminum has a modulus of elasticity E = 75 GPa. If the maximum permissible elongation of the wire is 3.0 mm and the allowable stress in tension is 60 MPa, the allowable load P_{max} is most nearly
   (a) 189 N
   (b) 186 N
   (c) 183 N
   (d) 180 N
   (e) 177 N



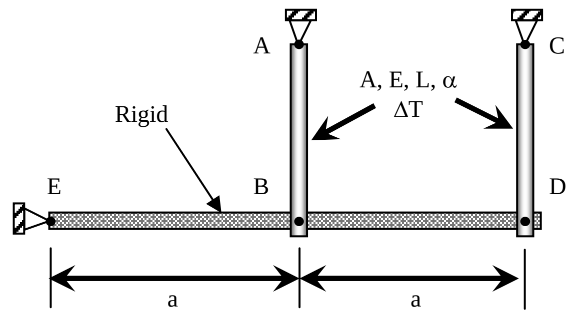
8. Knowing that σ_{all} = 120 MPa, the maximum allowable value of the centric axial load **P** is most nearly
   (a) 54.3 kN
   (b) 41.7 kN
   (c) 143.9 kN
   (d) 90.0 kN
   (e) 35.3 kN



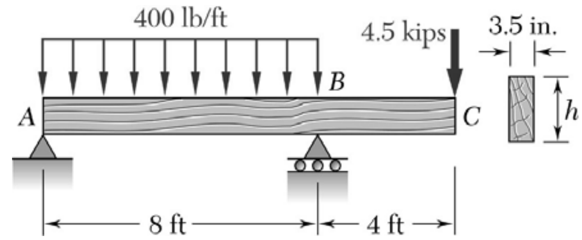
9. A spherical gas container having an outer diameter of 15 ft and a wall thickness of 0.90 in. is made of a steel for which $E = 29\text{x}10^6$ psi and $\nu = 0.29$. Knowing that the gage pressure in the container is increased from zero to 250 psi, the maximum normal stress in the container is most nearly
   (a) 55.3 ksi
   (b) 49.5 ksi
   (c) 24.8 ksi
   (d) 12.38 ksi
   (e) 6.19 ksi

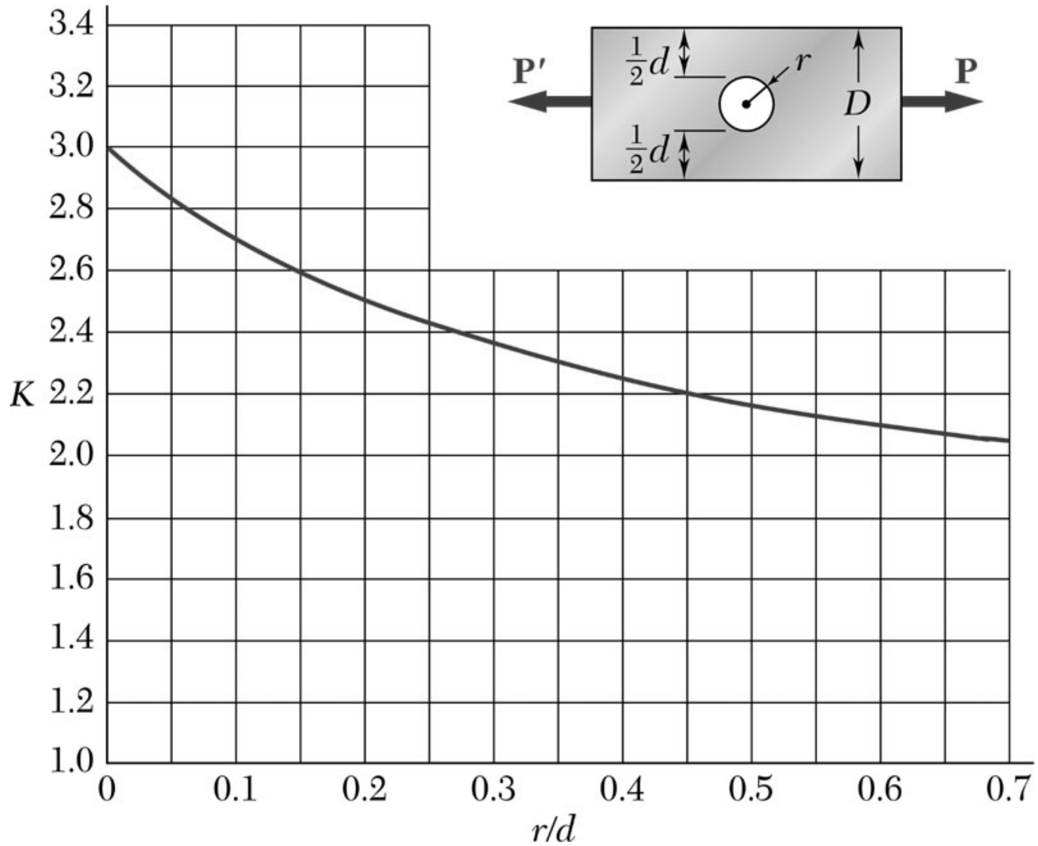
PART II: WORK OUT PROBLEMS (23 Points Each)

1. The rigid beam ED of length 2a is supported by the two identical rods AB and CD as shown below. The rods are made from a material with a modulus of elasticity E, a coefficient of thermal expansion α, cross-sectional area A, and length L. If the rods AB and CD are subjected to a temperature difference ΔT ($\Delta T>0$), find the deflection of point D in terms of E, α, A, L, a, and ΔT.



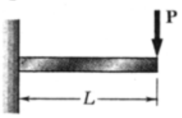
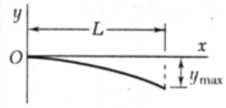
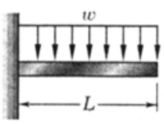
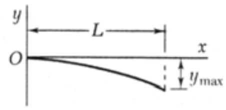
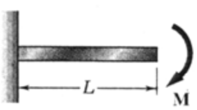
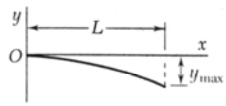
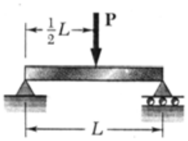
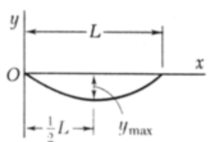
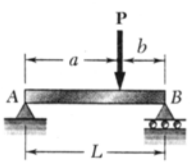
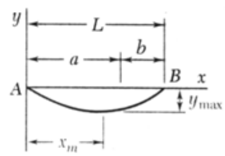
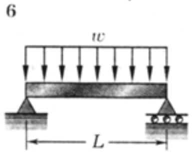
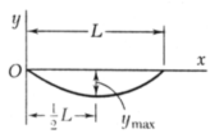
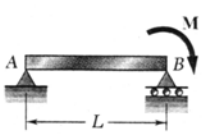
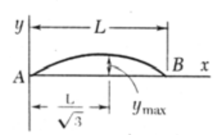
2. A 12-ft-long overhanging timber beam *AC* with an 8-ft span *AB* is to be designed to support the distributed and concentrated loads shown. Knowing that timber of 4-in. nominal width (3.5-in. actual width) with a 1.75-ksi allowable stress is to be used, determine the minimum required depth *h* of the beam.





Stress concentration factor for flat bars under axial loading.

Note that the average stress must be computed across the narrowest section: $\sigma_{ave} = P/td$ where t is the thickness of the bar.

Beam and Loading	Elastic Curve	Maximum Deflection	Slope at End	Equation of Elastic Curve
1 		$-\dfrac{PL^3}{3EI}$	$-\dfrac{PL^2}{2EI}$	$y = \dfrac{P}{6EI}(x^3 - 3Lx^2)$
2 		$-\dfrac{wL^4}{8EI}$	$-\dfrac{wL^3}{6EI}$	$y = -\dfrac{w}{24EI}(x^4 - 4Lx^3 + 6L^2x^2)$
3 		$-\dfrac{ML^2}{2EI}$	$-\dfrac{ML}{EI}$	$y = -\dfrac{M}{2EI}x^2$
4 		$-\dfrac{PL^3}{48EI}$	$\pm\dfrac{PL^2}{16EI}$	For $x \leq \frac{1}{2}L$: $y = \dfrac{P}{48EI}(4x^3 - 3L^2x)$
5 		For $a > b$: $-\dfrac{Pb(L^2 - b^2)^{3/2}}{9\sqrt{3}EIL}$ at $x_m = \sqrt{\dfrac{L^2 - b^2}{3}}$	$\theta_A = -\dfrac{Pb(L^2 - b^2)}{6EIL}$ $\theta_B = +\dfrac{Pa(L^2 - a^2)}{6EIL}$	For $x < a$: $y = \dfrac{Pb}{6EIL}[x^3 - (L^2 - b^2)x]$ For $x = a$: $y = -\dfrac{Pa^2b^2}{3EIL}$
6 		$-\dfrac{5wL^4}{384EI}$	$\pm\dfrac{wL^3}{24EI}$	$y = -\dfrac{w}{24EI}(x^4 - 2Lx^3 + L^3x)$
7 		$\dfrac{ML^2}{9\sqrt{3}EI}$	$\theta_A = +\dfrac{ML}{6EI}$ $\theta_B = -\dfrac{ML}{3EI}$	$y = -\dfrac{M}{6EIL}(x^3 - L^2x)$