ESM 2204 FINAL EXAMINATION MECHANICS OF DEFORMABLE BODIES

NAME (print)________________**SAMPLE EXAM**________________________

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.

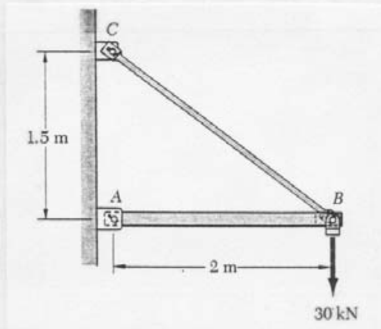
There are 12 questions on this exam – check for completeness. Part I (40%) consists of 10 multiple-choice problems (each problem is worth equal credit). Part II (60%) consists of two work-out problems (each problem is worth equal credit). For Parts I and II do your work directly on the pages provided.

CHECK FOR COMPLETENESS

PART I

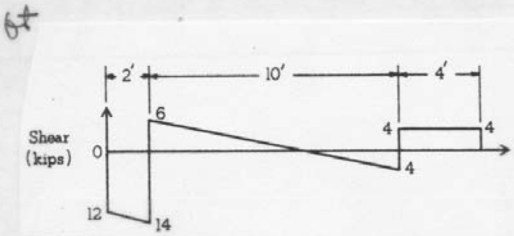
1. Determine the normal stress at the midpoint of rod *BC* which has a diameter of *40 mm*.
   a. 99.5 MPa
   b. 39.8 MPa
   c. 30.0 MPa
   d. 29.8 MPa
   e. 23.9 MPa
   f. 19.89 MPa

39.8 MPa



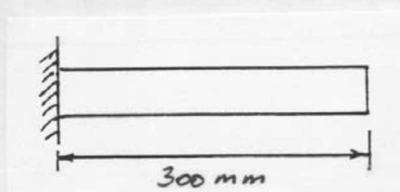
2. The shear diagram for a 16 ft long beam simply supported at each end is shown below. All lines in the shear diagram are straight. The moment at each end is zero. There are no concentrated couples (moments) along the beam. The magnitude of the maximum bending moment in the beam is
   a. 8,000 lb. ft
   b. 16,000 lb. ft
   c. 18,000 lb ft
   d. 26,000 lb. ft
   e. 34,000 lb. ft
   f. 38,000 lb. ft

26,000 lb.ft



3. The circular rod of 25 mm diameter undergoes a temperature change of 20° C. If $E = 200\ GPa$, $\upsilon = 0.3$, and $\alpha = 12 \times 10^{-6} / ° C$, determine the change in diameter of the rod.
   a. zero
   b. 0.000240 mm
   c. 0.001800 mm
   d. 0.00600 mm
   e. 0.0720 mm
   f. none of the above

$6(10^{-3})$ mm

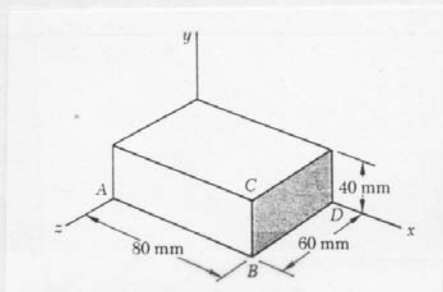


4. A 9 kN tensile load will be applied to a 50 m length of steel wire ($E = 200\ GPa$). Determine the smallest diameter wire which may be used, knowing that the normal stress may not exceed *150 MPa* and that the increase in the length of the wire should be at most *25 mm*.
   a. 1.514 mm
   b. 4.37 mm
   c. 5.35 mm
   d. 8.74 mm
   e. 10.70 mm
   f. 21.4 mm

10.70 mm

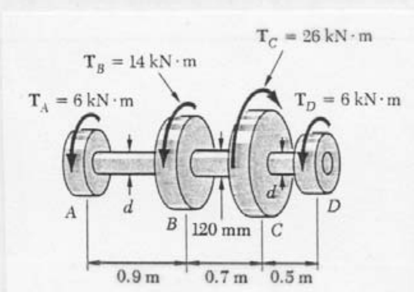
5. A steel ($E = 200\ GPa$, $\upsilon = 0.30$) block is subjected to a uniform pressure of *120 MPa* on all its faces. Determine the change in length of side *BD*
   a. -0.0360 mm
   b. +0.01440 mm
   c. +0.00240 mm
   d. +0.000600 mm
   e. -0.01440 mm
   f. -0.00240 mm

-0.01440 mm



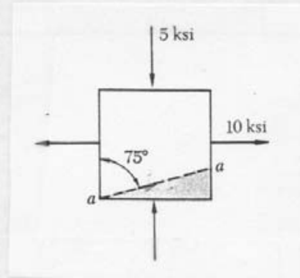
6. Shaft *ABCD* is solid with a constant diameter $d = 120\ mm$. For the loading shown determine the maximum shearing stress in segment *BC*.
   a. 7.37 MPa
   b. 17.68 MPa
   c. 41.3 MPa
   d. 58.9 MPa
   e. 76.6 MPa
   f. 117.9 MPa

58.9 MPa



7. For the state of stress shown, determine the magnitude and direction of the shearing stress on a plane parallel to a –a.
   a. 1.250 ksi ←
   b. 1.250 ksi →
   c. 4.60 ksi →
   d. 3.75 ksi →
   e. 7.41 ksi ←
   f. 3.75 ksi ←

3.75 ksi ←



8. Determine the critical buckling load of a wooden ($E = 12\ GPa$) stick one meter long which has a *7 x 24 mm* rectangular cross section. The ends are pinned.
   a. 0.483 N
   b. 5.68 N
   c. 20.3 N
   d. 25.8 N
   e. 81.2 N
   f. 955 N

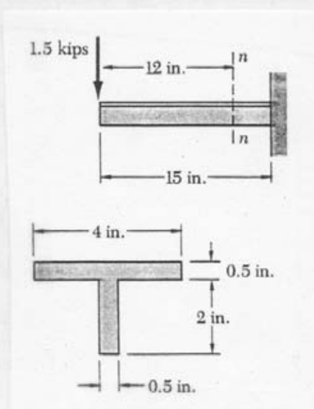
81.2 N

9. A spherical pressure vessel made of steel is *15 ft* in diameter (outside) and has a uniform wall thickness of *0.40 in*. For an internal pressure of *60 psi*, determine the maximum shearing stress in the vessel.
   a. 13,440 psi
   b. 10,080 psi
   c. 6720 psi
   d. 3360 psi
   e. zero
   f. none of the above

3360 psi

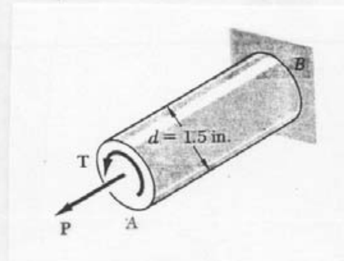
10. A beam has a T-shaped cross section shown. For the cross section the horizontal neutral axis is located *1.833 in.* above the bottom of the section, and the moment of inertia about this axis is $1.417\ in.^4$ For section n-n, determine the maximum shearing stress.
   a. 11,640 psi
   b. 6000 psi
   c. 1778 psi
   d. 750 psi
   e. 500 psi
   f. 222 psi

1778 psi



PART II

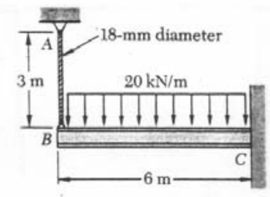
11. The *1.5 in.* diameter solid shaft is subjected to an axial load $P = 40{,}000\ lb$ and a torque $T = 4000\ lb\text{-}in.$ Consider a point on top of the shaft and determine the principal stresses and maximum shearing stress. The directions of these stresses are not required. **SHOW ALL WORK**

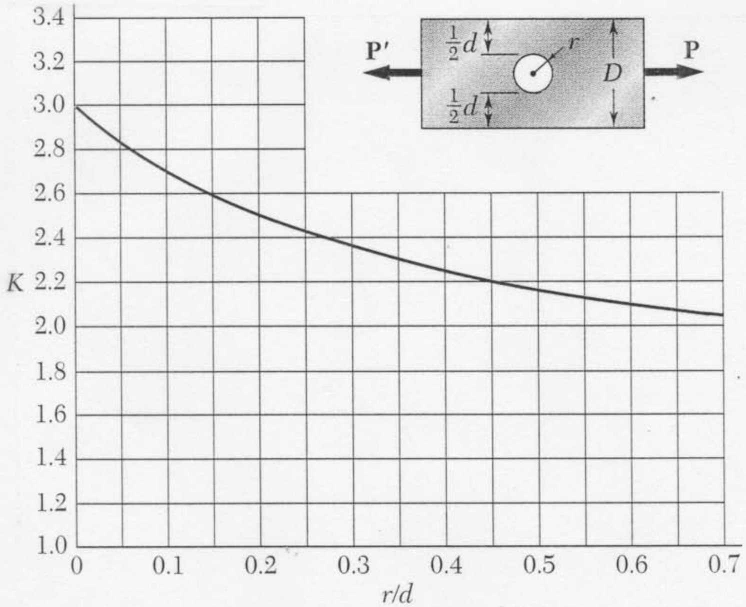


24.1 ksi
-1.509 ksi
12.83 ksi

12. The cantilever beam *BC* is attached to a cable *AB* as shown. Both the beam and cable are made of steel (*E* = *200 GPa*). The beam has a *200 x 200 mm* cross section. Knowing that the cable is initially taut, determine the tension in the cable caused by the distributed load shown. **SHOW ALL WORK**

44.0 kN

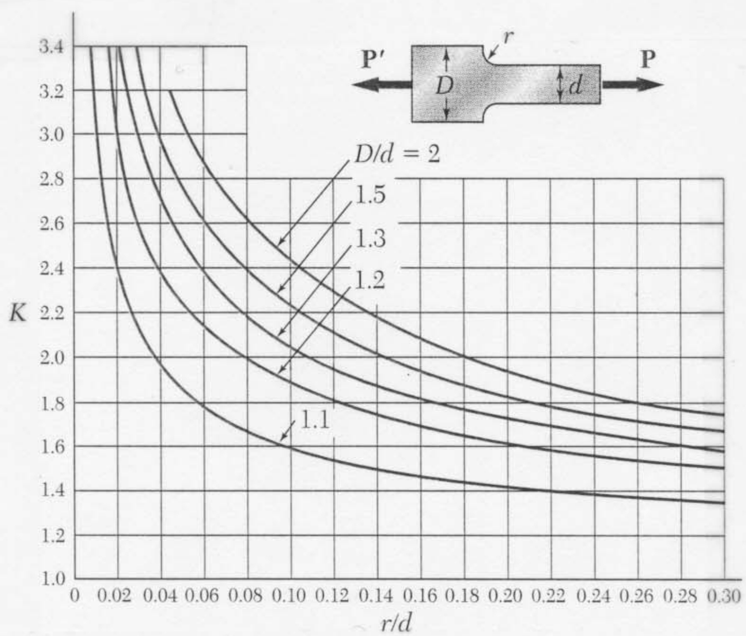




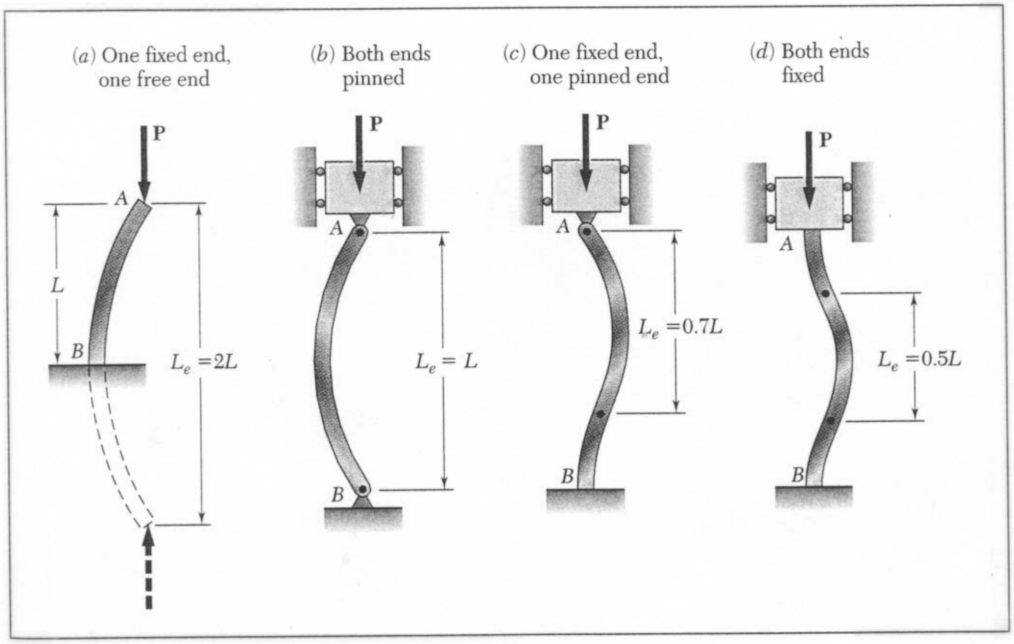
(*a*) Flat bars with holes

Stress concentration factors 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.

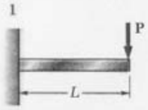
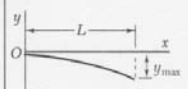
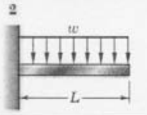
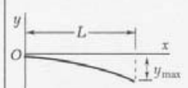
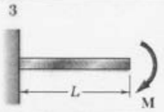
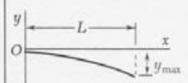
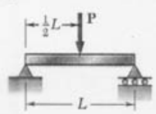
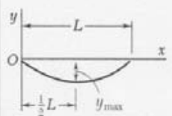
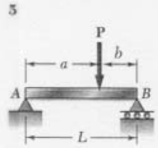
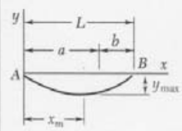
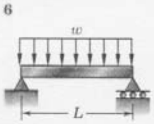
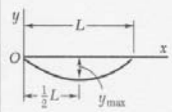
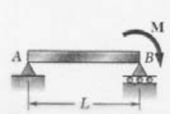
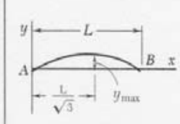


(*b*) Flat bars with fillets



Effective length of column for various end conditions.

Appendix. D. Beam Deflections and Slopes

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