The University of Texas at Austin

EM319 – Mechanics of Solids

Final Exam, Spring 2003

Time: 2-5pm, Thursday, May 8

Place: WCH 1.120

Name: _____

Unique number (circle one): 12320 12325

12330 12335

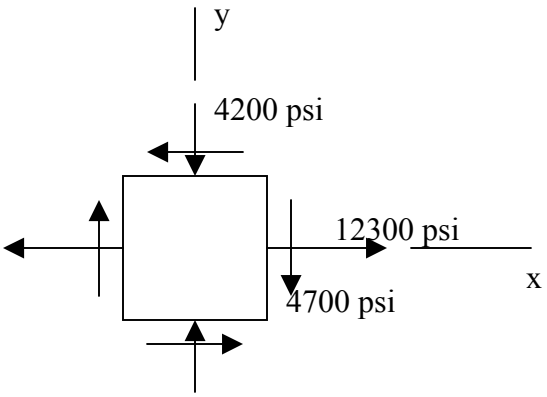
Closed books, notes, and homework.

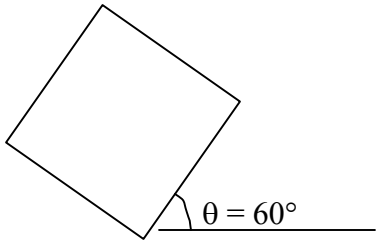
Allowed: one-page cheat sheet

Provided: Appendix G from the textbook, Tables of deflections and slopes of beams.

1. An element in plane stress is subject to stresses σ_x = 12300 psi, , σ_y = -4200 psi, and τ_{xy} = -4700 psi, as shown below.

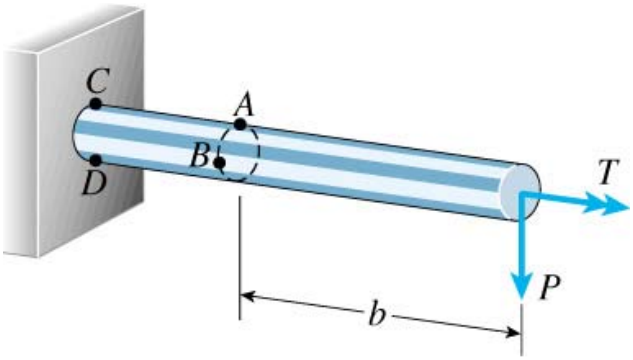
(a) Determine the principal stresses and the maximum shear stress (consider in-plane stresses only); (10)
(b) Determine the stresses acting on an element orientated at an angle θ = 60° from the *x* axis and show them on the sketch below. (10)





Answer: (a) Principle stresses are 13545 psi and –5445 psi, and the maximum shear stress is 9495 psi. (b) σ_{x1} = -4145 psi, σ_{y1} = 12245 psi, τ_{x1y1} = -4795 psi.

2. A cantilever bar of circular cross section shown below is subjected to a torque T = 2 kN-m and a vertical load P = 10 kN, both acting at the free end. The total length of the bar is L = 1.5 m, and b = 1 m. The diameter of the bar is d = 50 mm. Point A and C are located at the top of the bar, point B is located at the side of the bar at mid-height, and point D is located at bottom. Determine the stresses acting on each of the four points and show them on the corresponding stress elements below. (20)



A	B	C	D

Answer:

A: σ_x = 814 MPa, σ_y = 0, τ_{xy} = 81.5 MPa;

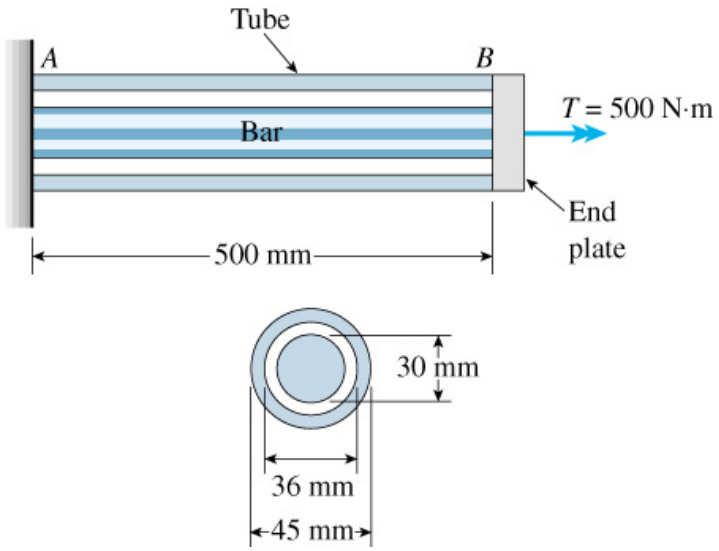
B: σ_x = 0, σ_y = 0, τ_{xy} = 88.2 MPa;

C: σ_x = 1222 MPa, σ_y = 0, τ_{xy} = 81.5 MPa;

D: σ_x = -1222 MPa, σ_y = 0, τ_{xy} = 81.5 MPa.

3. A solid bar of diameter 30 mm is enclosed by a tube of outer diamter 45 mm and inner diameter 36 mm (see figure below). Both the bar and the tube are held rigidly at end A and joined securely to a rigid plate at end B. The composite bar, which is 500 mm long, is twisted by a torque T = 500 N-m acting on the end plate. The shear modulus of the solid bar is 50 GPa and the shear modulus of the tube is 80 GPa.

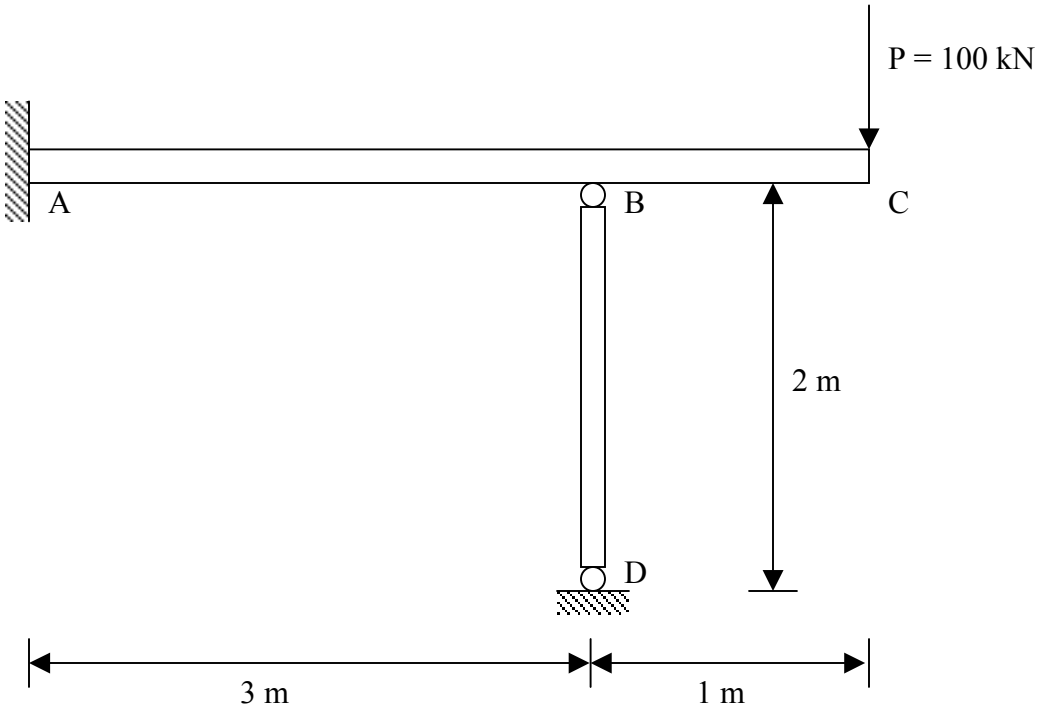
(a) Determine the angle of rotation of the end plate at B; (10)
(b) Determine the maximum shear stresses in the bar and the tube, respectively. (10)



Answer: (a) 0.63° (0.011 rad); (b) 16.4 MPa in the bar and 39.0 MPa in the tube.

4. A horizontal beam ABC is fixed at end A and supported at B by a pinned-end column BD (see figure below). A concentrated load P = 100 kN acts at the end C. Both the beam and the column have the same Young's modulus, E = 200 GPa. The beam has a rectangular cross section with width b = 6 cm and height h = 20 cm. The column has a circular cross section with diameter d = 6 cm.

(a) Determine the reactions at A and D; (10)
(b) Determine the deflections at B and C; (10)
(c) Determine the maximum stresses in the beam and the column; (10)
(d) Determine the critical load at C for the column to buckle. (10)



Answer: (a) 50 kN and 50 kN-m (moment) at A and 150 kN at D; (b) 0.53 mm at B and 13.5 mm at C; (c) Maximum bending stress in the beam is 25 MPa and maximum shear stress in the beam is 12.5 MPa; maximum normal stress in the column is 53 MPa; (d) 209 kN.