Carleton UNIVERSITY

Final
EXAMINATION
December 2008

DURATION: 3 HOURS **No. of Students: 120**

Department name & Course Number: Civil and Environmental Engineering Department

Mechanics of Solids – CIVE 2200

Course Instructor: Dr. Ehab Zalok

AUTHORIZED MEMORANDA

(1) Closed book exam.
(2) Formula sheet is provided, and
   - ✓ Hand in the formula sheet with your exam paper.
(3) Programmable calculators are NOT allowed.
(4) Questions carry equal weight.
(5) Answer all questions.

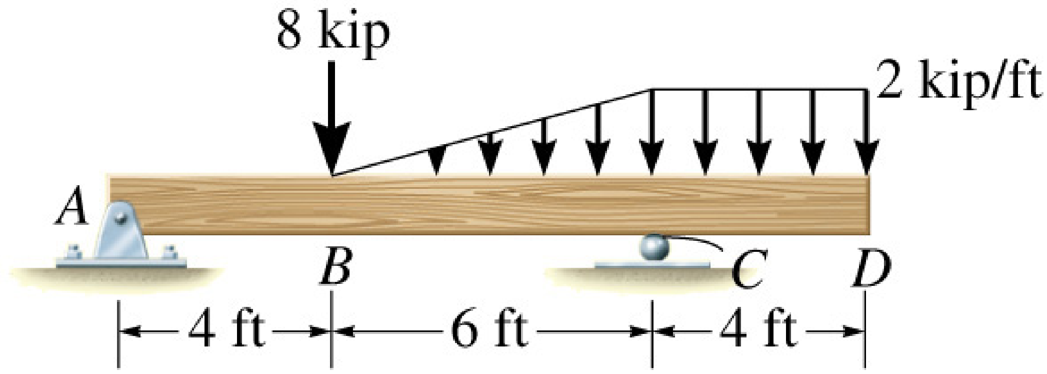
Students MUST count the number of pages in this examination question before beginning to write, and report any discrepancy to a proctor. This question paper has **5** pages.

This examination question paper **MAY NOT** be taken from the examination room.

In addition to this question paper, students require: an additional booklet yes ■ no ☐
a Scantron sheet yes ☐ no ■

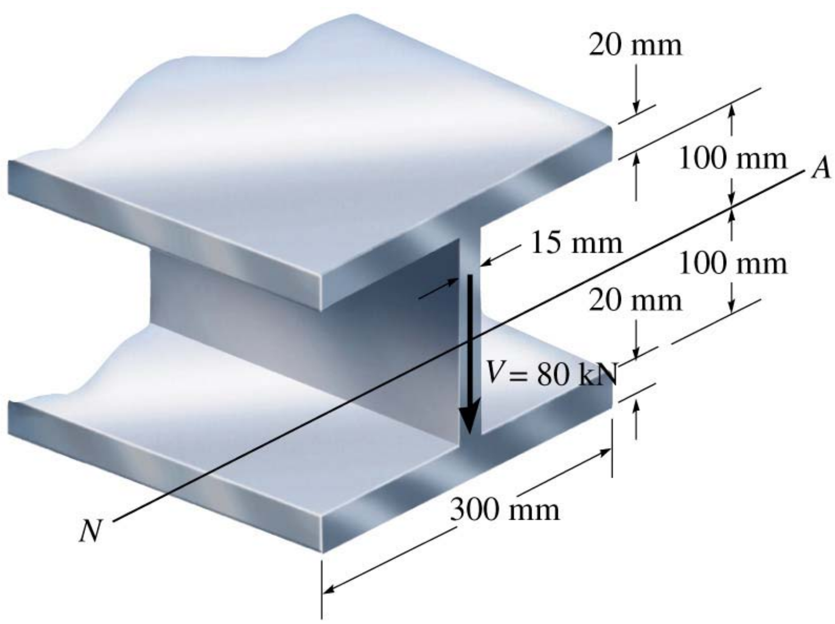
Question One

Draw the shear and moment diagrams for the overhanging beam shown in the figure below.



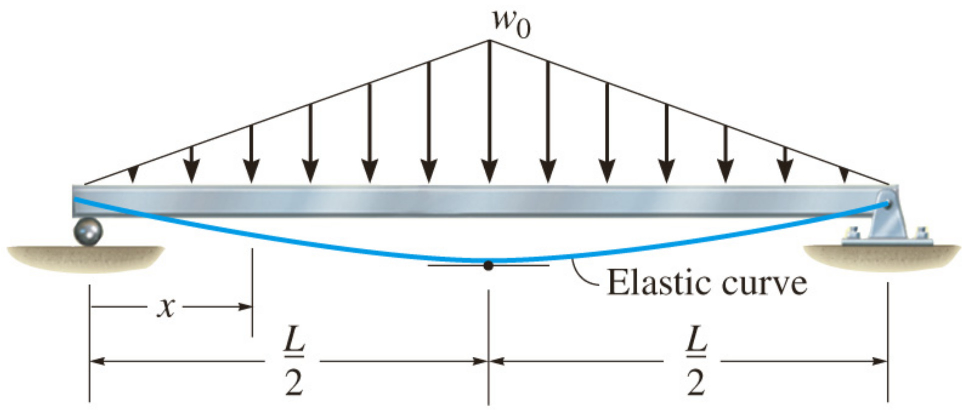
Question two

A steel wide-flange beam has the dimensions shown in the figure below. If it is subjected to a shear of V = 80 kN; plot the shear-stress distribution acting over the beam's cross–sectional area.



Question Three

The simply supported beam shown below supports the triangular distributed loading. Determine its maximum deflection. *EI* is constant.



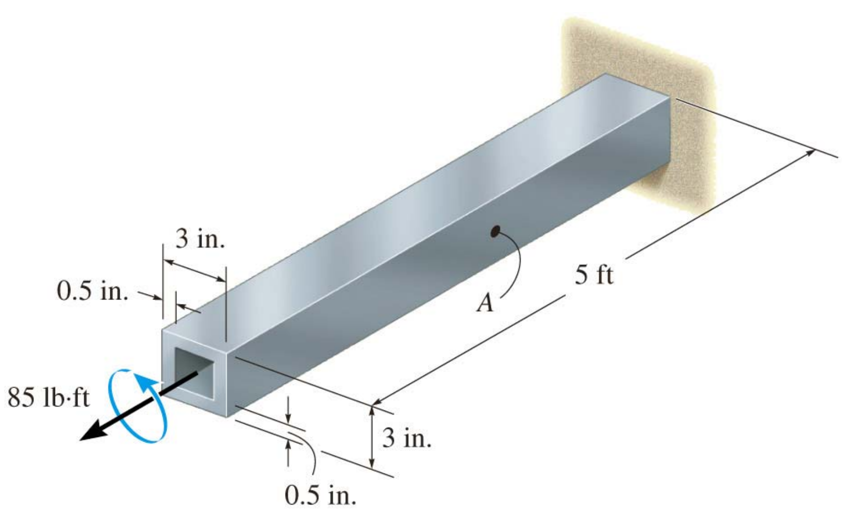
Question Four

A square aluminum tube has the dimensions shown in Figure below.

(a) Determine the average shear stress in the tube at point A if it is subjected to a torque of 85 lb.ft.

(b) Compute the angle of twist due to this loading.

Take G_{al}=3.80 (10^3) ksi.

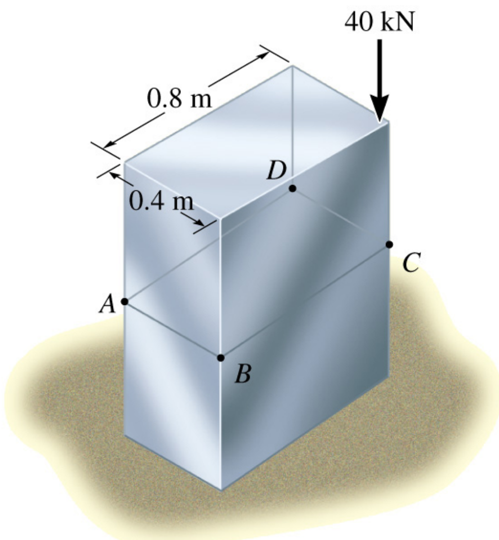


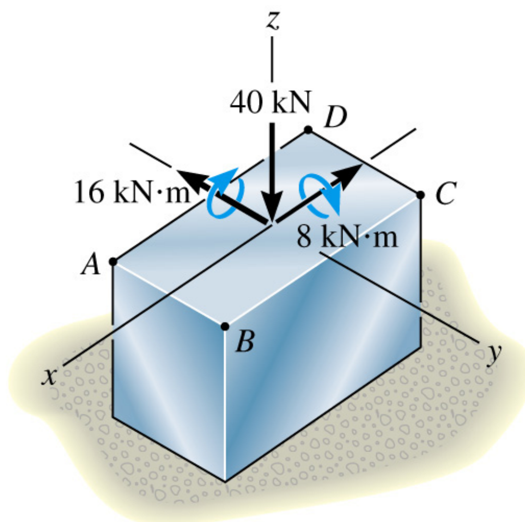
Question Five

The rectangular block of negligible weight in the left Figure is subjected to a vertical force of 40 kN, which is applied to its corner. The right Figure shows the effect of the 40 kN force at a section through ABCD.

Determine the normal-stress distribution acting on the section through ABCD.

HINT: Calculate the stresses at points A, B, C, and D.



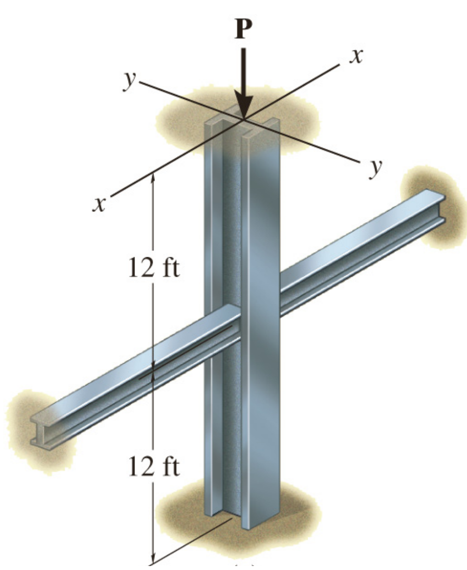


Question Six

A W6 x 15 steel column is 24 ft long and is fixed at its ends as shown in the figure. Its load-carrying is increased by bracing it about the y-y axis using struts that are assumed to be pin-connected to its midheight.

Determine the load it can support so that (a) the column does not buckle nor (b) the material exceed the yield stress.

For the W6 x 15 section; take: $I_x = 29.1 in^4$, $I_y = 9.32 in^4$, $E_{st} = 29(10^3) ksi$, $\sigma_y = 60 ksi$, A = 4.43 in^2



Question Seven

About Mohr's Circle:

Axial Loading

Normal stress

$$\sigma = \frac{P}{A}$$

Displacement

$$\Delta = \frac{PL}{AE}$$

Torsion

Shear stress in a circular shaft

$$\tau = \frac{T\rho}{I_p}$$

Angle of twist of circular member

$$\phi = \frac{TL}{I_p G}$$

Shear stress in a rectangular shaft

$$\tau = \frac{T}{\alpha\, bt^2}$$

Shear stress in a thin-walled tube

$$\tau = \frac{T}{2t\textcircled{A}}$$

Stress Transformation

Principal normal stresses

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Maximum and minimum shear stresses

$$\tau_{\substack{\max\\ \min}} = \pm\sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Bending

Normal stress in a straight member

$$\sigma = -\frac{My}{I}$$

Unsymmetric bending

$$\sigma_x = -\frac{M_z y}{I_z} + \frac{M_y z}{I_y}$$

$$\tan\beta = \frac{I_z}{I_y}\tan\alpha$$

Shear

Shear flow and stress due to shear force

$$q = \tau t = \frac{VQ}{I}, \qquad \tau = \frac{VQ}{It}$$

Mechanical Properties of Material

Poisson's ratio

$$\nu = -\frac{\varepsilon_{\text{lat}}}{\varepsilon_{\text{long}}}$$

Generalized Hooke's Law

$$\varepsilon_x = \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)], \qquad \gamma_{xy} = \frac{\tau_{xy}}{G}$$

$$\varepsilon_y = \frac{1}{E}[\sigma_y - \nu(\sigma_z + \sigma_x)], \qquad \gamma_{yz} = \frac{\tau_{yz}}{G}$$

$$\varepsilon_z = \frac{1}{E}[\sigma_z - \nu(\sigma_x + \sigma_y)], \qquad \gamma_{zx} = \frac{\tau_{zx}}{G}$$

where shear modulus

$$G = \frac{E}{2(1+\nu)}$$

Dilatation

$$e = \frac{1-2\nu}{E}(\sigma_x + \sigma_y + \sigma_z)$$

Bulk modulus

$$k = \frac{E}{3(1-2\nu)}$$

Deflection of Beams

Relations between q, V, M

$$\frac{dV}{dx} = q(x), \qquad \frac{dM}{dx} = V(x)$$

Elastic curve

$$\frac{1}{\rho} = \frac{M}{EI}, \qquad EI\frac{d^4v}{dx^4} = q(x)$$

$$EI\frac{d^3v}{dx^3} = V(x), \qquad EI\frac{d^2v}{dx^2} = M(x)$$

Buckling

Critical axial load

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2}$$

Critical axial stress

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 E}{(KL/r)^2}$$

Radius of gyration

$$r = r_{\min} = \sqrt{\frac{I_{\min}}{A}}$$