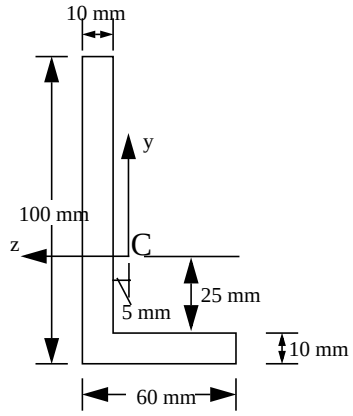
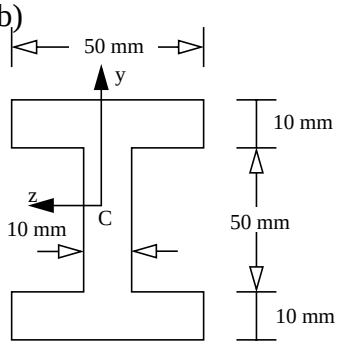
EXAM 2 MEEM 4150 Nov. 19th, 2003

1. (a) Determine I_{yz} for the L shaped cross-section shown in Fig. (a).

(a)



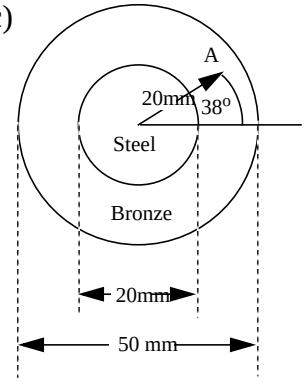
(b)



$I_{yy} = 0.463(10^6)\ \text{mm}^4$

$I_{zz} = 1.013(10^6)\ \text{mm}^4$

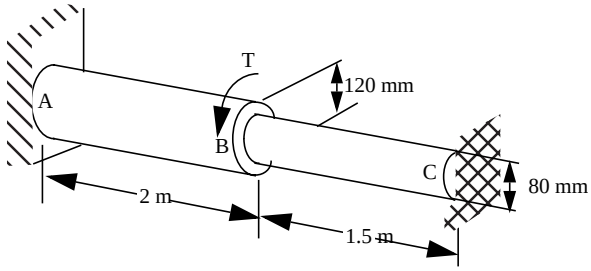
(c)



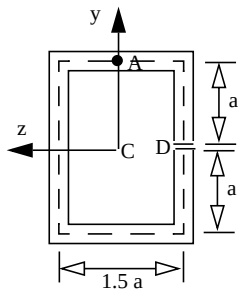
(b) The internal bending moments on a cross-section shown in Fig. (b) were determined to be $\boldsymbol{M}_y = -20\ \text{kN}-\text{m}$ and $\boldsymbol{M}_z = -25\ \text{kN}-\text{m}$. Determine the orientation of the neutral axis and show it on the cross-section.

(c) The torsional shear strain at point A on a cross-section shown in Fig. (c) was found to be 1000 μ. If the shear modulus of steel is G_{steel} = 80 GPa and for the bronze is G_{bronze} = 40 GPa, determine the maximum shear stress in steel.

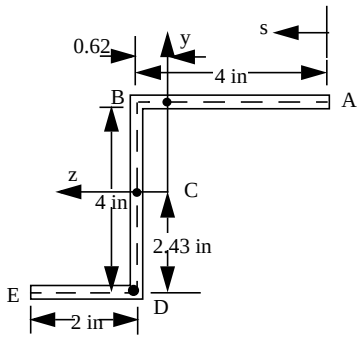
(d)



(e)



(f)

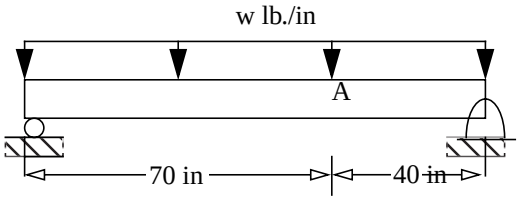


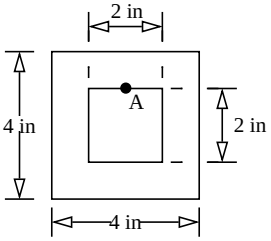
(d) A circular shaft made of elastic-perfectly plastic material has a yield stress of τ_{yield} = 160 MPa. and a shear modulus of G = 80 GPa. Under the action of torque, section B of shaft shown in Fig. (d) was seen to rotate by 0.12 rads. Determine the depth of the plastic zone in segment BC of the shaft.

(e) A thin cross-section of uniform thickness t is shown in Fig. (e). If shear stresses were to be found at point A then what values of Q_y and Q_z are needed for the calculation. Assume $t \ll a$ and gap at D is of negligible thickness. Report the values of Q_y and Q_z in terms of t and a.

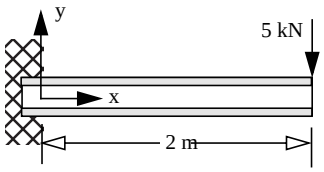
(f) The shear flow in section AB of the cross-section shown in Fig. (f) was found to be $q = -(0.0340s^2 - 0.1085s)\boldsymbol{V}_y - (0.0550s^2 - 0.2646s)\boldsymbol{V}_z$, where $\boldsymbol{V}_y$ and $\boldsymbol{V}_z$ are the internal shear forces in the positive y and z direction, and s is measured from point A. Determine the location of the shear center with respect to point D.

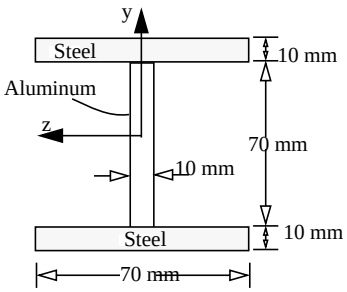
2. A uniformly loaded simply supported beam is made of elastic-perfectly plastic material that has a yield stress of 30 ksi. The beam has the hollow square cross-section as shown. If point A is at yield stress, determine (a) the equivalent internal moment at the cross-section containing point A. (b) the intensity w of the uniform load





3. A steel $E_{steel} = 200\ GPa$ strip is attached to a aluminum $E_{Al} = 70\ GPa$ beam to form a composite cantilever beam as shown. Determine the maximum bending normal and shear stress in steel and aluminum.





ANSWERS

(1a) $I_{yz} = 450\ (10^3)\ mm^4$ (b) $\beta_{NA} = -60.3^o$ (c) $(\tau_{steel})_{max} = 40$ MPa (d) $(depth)_{BC} = 15$ mm

(e) $Q_y = -1.031\ a^2t$ $Q_z = 1.25\ a^2t$ (f) $e_y = 3.755$ in $e_z = -0.571$ in

2. $\boldsymbol{M}_z = 400$ in-lb w = 285.7 lb/in

3. $(\sigma_{steel})_{max} = 191.4$ MPa (T) or (C) $(\sigma_{Al})_{max} = 52.1$ MPa (T) or (C)

$(\tau_{steel})_{max} = 5.94$ MPa $(\tau_{Al})_{max} = 6.4$ MPa