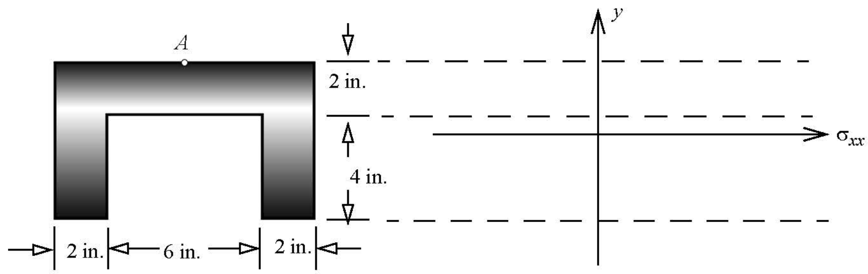
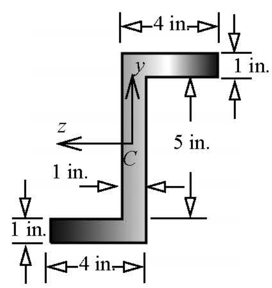
EXAM 2 MEEM 4150 April 7, 2015

1.

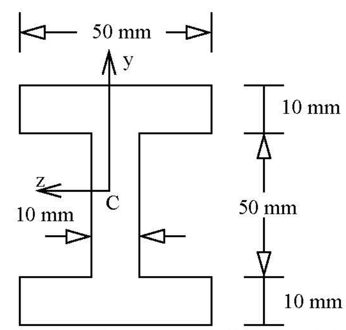
(i) A beam of elastic-perfectly plastic material has a yield stress of 50 *ksi*. Point *A* on the cross-section shown just reaches yield stress in *compression* at a given load. (i) Sketch the stress distribution as a function of *y*. (ii) Write the expressions for bending normal stress σ_{xx}, dA and the intervals you would use to evaluate $N = \int_A \sigma_{xx} dA$. Use coordinate *y* and parameter '*a*' representing the distance of elastic-plastic boundary from neutral axis in writing your stress expressions. DO NOT EVALUATE THE INTEGRAL.



(ii) Determine the three second area moment of inertias I_{yy}, I_{zz}, and I_{yz} for the cross-section shown.



(iii) The internal bending moments on the cross section shown above were determined to be $M_y = -20\ kN-m$ and $M_z = -25\ kN-m$. Determine (a) the orientation of the neutral axis and (b) the maximum bending normal stress.

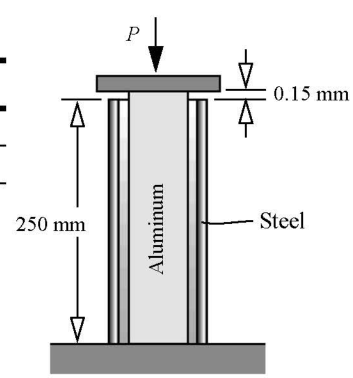


$I_{yy} = 0.463(10^6)\ mm^4$

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

2. Figure below shows an aluminum circular rod inside a steel tube. The aluminium rod is slightly longer than the steel tube and has a diameter of 40 mm. The steel tube has an inside diameter of 50 mm and and outside diameter of 70 mm. If the applied load *P* = 200 kN and the temperature is *decreased* by 100^oC, determine the deformation of aluminium rod and the axial stress in the steel tube.

	Aluminum	Steel
Modulus of elasticity	70 GPa	210 GPa,
Coefficient of thermal expansion.	$23.2\mu/^oC$	$11.7\mu/^oC$



3. The table below gives the material properties of titanium and aluminum. The figures shown are cross sections of either axial rod, or a shaft, or a beam. Use this information to answer questions (i) through (v).

	Titanium	Aluminum
Modulus of elasticity	100 GPa	70 GPa
Shear modulus of elasticity	36 GPa	28 GPa

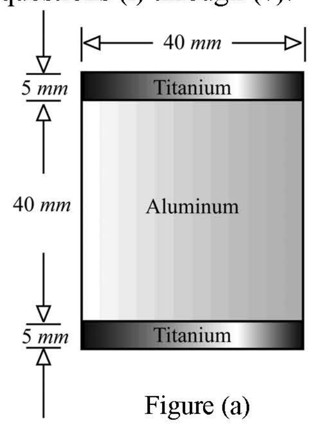


Figure (a)

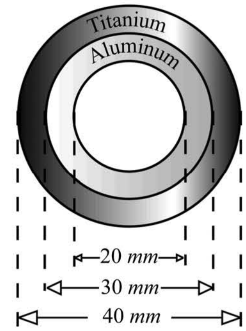


Figure (b)

(i) In Figure (*a*) the maximum *bending* normal strain in titanium was found to be 0.0004. The maximum bending normal stress in aluminum is σ_{max} =

(ii) In Figure (*b*) the maximum *torsional shear strain* in aluminum was found to be 0.0003. The maximum torsional shear stress in titanium is τ_{max} =

(iii) The internal torque acting on the cross section Figure (*b*) is 3.8 kN-m. The maximum *torsional shear stress* in aluminum is τ_{max} =

(iv) The internal bending moment acting on the cross section in Figure (*a*) is 2.5 kN-m. The maximum *bending normal stress* in aluminum is σ_{max} =

(v) The internal bending shear force acting on the cross section in Figure (*a*) is 50 kN. The maximum *bending shear stress* in aluminum is τ_{max} =

In questions below assume the material is elastic-perfectly plastic with properties given in the table below. Using this information to answer questions (vi) through (ix).

Modulus of elasticity	30,000 ksi
Shear modulus of elasticity	12,000 ksi
Normal yield stress	30 ksi
Shear yield stress	18 ksi

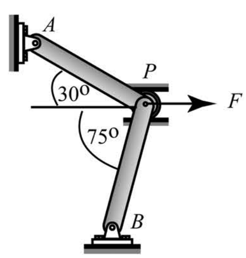


Figure (c)

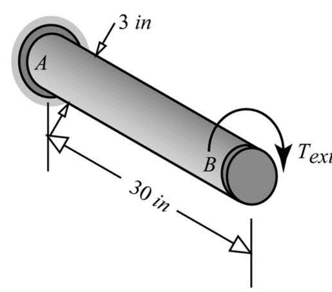


Figure (d)

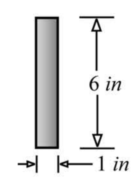


Figure (e)

(vi) Each of the two bars in the structure shown in Figure (*c*) have lengths of 10 inch and cross sectional area of 0.16 inch^2. The collapse load is $F_{collapse}$ =

(vii) The circular shaft shown in Figure (*d*) is made from elastic-perfectly plastic material. Due to the action of the torque the section at *B* was seen to rotate by 0.15 radians. The depth of plastic zone in *AB* is *depth* =

(viii) The beam cross section shown in Figure (*e*) is made from elastic-perfectly plastic material. The depth of plastic zone is 0.5 inch. The maximum bending normal strain is ε_{max} =

(ix) The beam cross section shown in Figure (*e*) is made from elastic-perfectly plastic material. The magnitude of collapse moment is M_p =

ANSWERS

1. (ii) $I_{yy} = 29.08\ \text{in}^4$; $I_{zz} = 83.08\ \text{in}^4$; $I_{yz} = -36\ \text{in}^4$

(iii) $\beta = -60.26°$ $\sigma_{max} = 19.44$ MPa (T) or (C)

2. $\delta_{al} = 0.569$mm ; $\sigma_s = 106.3$ MPa (C)

3. (i) $\sigma_{max} = 22.4$ MPa (T) or (C) ; (ii) $\tau_{max} = 14.4$ MPa ; (iii) $\tau_{max} = 200.2$ MPa ; (iv) $\sigma_{max} = 99.4$ MPa ; (v) $\tau_{max} = 35.8$ MPa ; (vi) $F_{collapse} = 5.4$ kips (vii) $depth = 1.2$ inch (viii) $\varepsilon_{max} = 1200\ \mu$; (ix) $M_p = 270$ in-kips