Final MEEM 4150 April 29, 2015

1. The statements below are either true or false. **Circle** the correct answer.

(i) Positive shear strain results in increase of angle from a right angle. True / False

(ii) The Generalized Hooke's law is valid for non-homogeneous, isotropic material. True / False

(iii) The equation $N = \int_A \sigma_{xx}\, dA$ *cannot* be used for nonlinear materials. True / False

(iv) The equation $T = \int_A \rho\, \tau_{x\theta}\, dA$ *can* be used for a non-homogeneous cross section. True / False

(v) The formula $\sigma_{xx} = -M_z y / I_{zz}$ *can* be used to find the normal stress on a cross section of a tapered beam. True / False

(vi) If the cross area moment of inertia $I_{yz} = 0$, then buckling will take place either about the y or z axis. True / False

(vii) The location of the shear center depends upon the loads applied. True / False

(viii) Virtual work theorem is applicable to non-linear systems. True / False

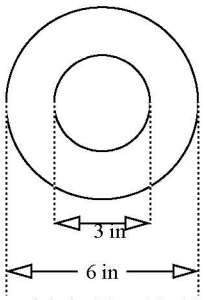
(ix) Kinematic admissible functions must satisfy boundary conditions on forces and moments. True / False

(x) Virtual displacement must be kinematically admissible. True / False

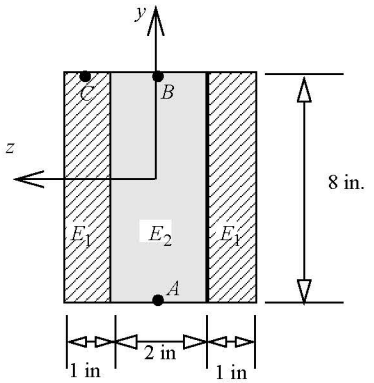
2. (a) The principal angles for a principal direction associated with the given stress matrix were found to be $\theta_x = 114.9^o$, $\theta_y = 77.8^o$, and $\theta_z = 28.1^o$. Determine the principal stress associated with the direction.

$$\begin{bmatrix} 30 & 0 & 20 \\ 0 & 30 & -10 \\ 20 & -10 & 0 \end{bmatrix} MPa$$

(b) The torsional shear stress for a hollow shaft made from a non-linear material was found to be $\tau = 10\rho^{0.25}$ *ksi* . Determine the equivalent internal torque.



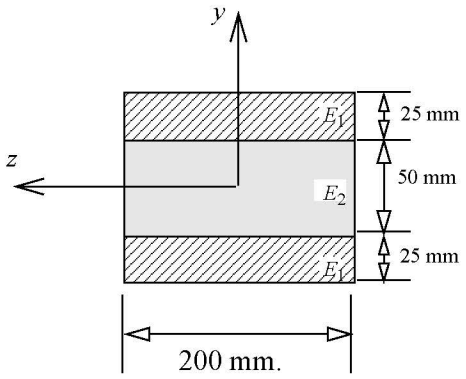
In parts (c) and (d) below use the composite cross-section shown in which E_1=10,000 ksi and E_2= 30,000 ksi. Point A is at the bottom of the cross-section and points B and C are at the top of the cross-section.



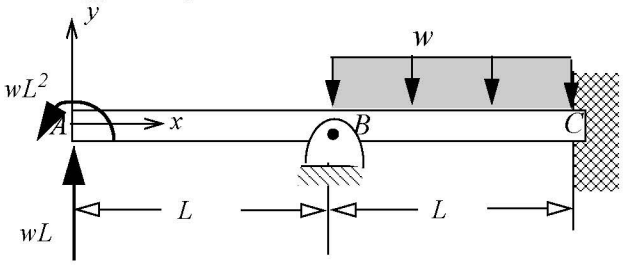
(c) The AXIAL normal stress at A is 16 ksi (T). What are the axial stresses at points B and C? Indicate tension or compression.

(d) The bending axis is the z-axis. The BENDING normal stress at A is 12 ksi (T). What are the bending normal stresses at B and C? Indicate tension or compression.

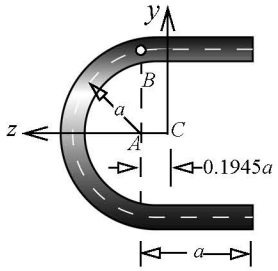
(e) The composite cross-section shown below has E_1= 200 GPa and E_2= 70 GPa. Due to bending about the z-axis, the shear force on the cross-section was found to be V_y = 20 kN . Determine the maximum shear stress in the cross-section.



3. (a) Write the boundary value problem to determine the equation of the elastic curve [v(x)]. All conditions must be in terms of v and **its derivatives**. *Do not integrate or solve.*
(b) Using an *energy method*, determine the reaction force at B in terms of w, E, I and L. Some variables may not appear in your result.



4. The cross section shown has a uniform thickness t and second area moment of inertias are I_{zz} = $3.571a^3t$ and I_{yy} = $2.043a^3t$ .Assume $t << a$.
(a) If the shear forces acting on the cross section are V_y = V_z = V, determine the shear stress at point B in terms of V, a, and t
(b) Determine the location of the shear center with respect to point A. Point A is the center of the circular arc.



ANSWERS

1. (i) False (ii) True (iii) False (iv) True (v) True (vi) True (vii) False (viii) True (ix) False (x) True

2. (a) σ_p =11.92 MPa (C)(b) $\boldsymbol{T}$ = 614.7 in-kips (c) σ_B = 16 ksi (T) ; σ_C = 5.33 ksi (T)

(d) σ_B = 12 ksi (C); σ_C = 4 ksi (C) (e) τ_{max} = 1.37 MPa.

3. R_B = $5wL/8$ downward

4. τ_B= -0.1305 V/at; e_y= 0; e_z= 1.72 a