UNIVERSITY OF CALIFORNIA, BERKELEY
Spring Semester, 2005

Department of Civil and Environmental Engineering
Instructor: A. K. Chopra

CE 130 – MIDTERM EXAMINATION NO. 1

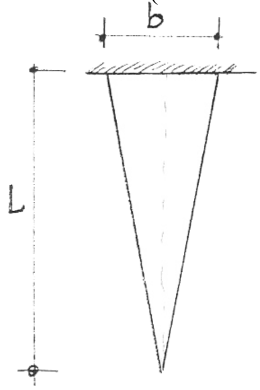
Please Note:

1. Write your answers on these sheets.
2. Show all computations; identify your answers.

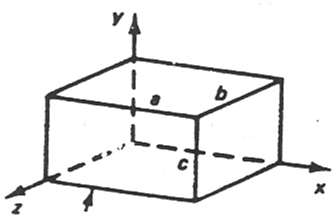
	Problems	Maximum Points	Points Scored
	1	10	
	2	10	
	3	10	
Total		30	

NAME: ____

1. The symmetric triangular piece shown in the figure is cut from a 1-in. thick plate. Determine the increase in length of this piece caused by its own weight when hung from the top. The weight density (or unit weight) of the material is γ; the elastic modulus is E.



2. A rectangular steel block such as shown has the following dimensions: $a = 50$ mm, $b = 75$ mm, and $c = 100$ mm. The faces of this block are subjected to uniformly distributed forces of 180 kN (tension) in the x-direction, 200 kN (tension) in the y-direction, and 240 kN (compression) in the z-direction. Determine the magnitude of a single system of forces acting only in the y-direction that would cause the same deformation in the y-direction as the initial forces. Let $v = 0.25$.



3. A hollow circular shaft of linearly elastic material of length L has an outside diameter of $d_0 = 4$ in., and inside diameter $d_i = 3$ in. Determine the minimum diameter d for a solid shaft of the same material to replace the hollow shaft so that in the new shaft neither the maximum stress nor the angle of twist exceed the same quantities in the original design.

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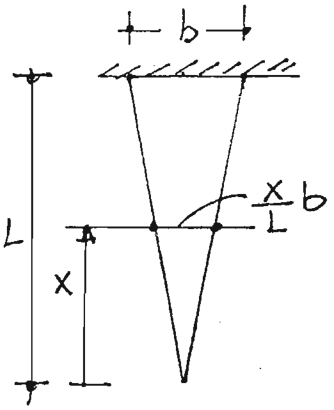

1. Axial force at x

$$R(x) = \gamma\left(\tfrac{1}{2}x \cdot \tfrac{x}{L}b \cdot 1\right) = \frac{1}{2}\frac{x^2 b}{L}\gamma$$

2. Cross sectional area at x

$$A(x) = \left(\frac{x}{L}b\right)1 = \frac{x}{L}b$$

3. Calculate Elongation

$$\Delta = \int_0^L \frac{R(x)}{A(x)E}\,dx$$

$$\Delta = \int_0^L \frac{1}{2}\frac{x^2 b}{L}\gamma \frac{1}{\frac{x}{L}bE}\,dx = \frac{\gamma}{2E}\int_0^L x\,dx = \boxed{\frac{\gamma L^2}{4E}}$$

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1. Deformation in y-direction

$$\Delta_y = \varepsilon_{yy}\, a$$

$$\varepsilon_{yy} = \frac{\sigma_{yy}}{E} - \frac{\nu(\sigma_{xx}+\sigma_{zz})}{E}$$

$$\varepsilon_{yy} = \frac{1}{E}\left\{\frac{200}{50\times 75} - \frac{1}{4}\left[\frac{180}{75\times 100} + \frac{(-240)}{50\times 100}\right]\right\}$$

$$= \frac{0.0593}{E} \quad (1)$$

2. Compute stresses

$$\sigma_{xx} = \frac{180}{75\times 100}$$

$$\sigma_{yy} = \frac{200}{50\times 75}$$

$$\sigma_{zz} = \frac{-240}{50\times 100}$$

3. Deformation due to P_y only $\quad \Delta y = \varepsilon_{yy}\, a$

$$\varepsilon_{yy} = \frac{P_y}{(50\times 75)E} \quad (2)$$

3. Equate Eqs (1) and (2) $\Rightarrow$ $\boxed{P_y = 223\text{ KN}}$

$$\tau_{max} = \frac{TR}{J} \qquad \phi = \frac{TL}{GJ}$$

Hollow shaft: $R = \frac{4}{2} = 2''$ $\qquad J = \frac{\pi(4^4-3^4)}{32} = \frac{175\pi}{32}$

Solid shaft: $R = D/2$ $\qquad J = \pi D^4/32$

Equal τ_{max} $\Rightarrow$ $\frac{T.2}{175\pi/32} = \frac{T.D/2}{\pi D^4/32}$ $\Rightarrow$ $D = 3.52$ in.

Equal ϕ $\Rightarrow$ $\frac{TL}{\frac{175\pi}{32}G} = \frac{TL}{\frac{\pi D^4}{32}G}$ $\Rightarrow$ $D = 3.64$ in

To satisfy both Criteria : $\boxed{D = 3.64\text{ in.}}$

No. 937 811E Engineer's Computation Pad STAEDTLER