ASSIGNMENTS FOR MEEG 4103 Machine Element Design

TR 9:30 a.m. -10:50 a.m. Spring 2009

4103-001 LEC 9897 Machine Element Design
4103H-001 LEC 10315 HNRS Machine Element Design

Text: *Shigley's Mechanical Engineering Design, Eighth Edition*
R. G. Budynas and J. K. Nisbett, McGraw-Hill, 2008

Supplies: Calculator, engineering paper, mechanical pencil, eraser, *transparent* 6-in. plastic ruler, and compass or template for drawing circles.

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Part *A*

Chapter 3

3-3a, 3-3b, 3-4, 3-8, 3-11, 3-13, 3-25b, 3-25d, 3-29, 3-38, 3-55

Chapter 4

4-13, 4-16, 4-18, 4-20, 4-21

4S-1. A Gerber beam (*Gerberbalken*) with total length $4L$ has a hinge connection at C and constant flexural rigidity EI in its segments ABC and CDE. This beam is supported and loaded with a concentrated moment M_0 ↺ at D as shown in Fig. 4S-1. Determine *(a)* the slopes θ_B, θ_D, and θ_E at B, D, and E, respectively; *(b)* the slope $(\theta_C)_l$ just to the left of C; *(c)* the slope $(\theta_C)_r$ just to the right of C; *(d)* the deflection y_C at C; *(e)* the deflection y_D at D.

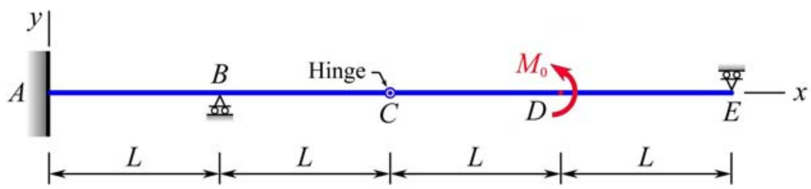

Fig. 4S-1 A Gerber beam

Ans.

$$\theta_B = \frac{M_0 L}{8EI} \circlearrowright \qquad \theta_D = \frac{5M_0 L}{16EI} \circlearrowleft \qquad \theta_E = \frac{M_0 L}{16EI} \circlearrowleft$$

$$(\theta_C)_l = \frac{3M_0 L}{8EI} \circlearrowright \qquad (\theta_C)_r = \frac{M_0 L}{16EI} \circlearrowleft \qquad y_C = \frac{7M_0 L^2}{24EI} \downarrow \qquad y_D = \frac{7M_0 L^2}{48EI} \downarrow$$

Chapter 5

5-1, 5-3, 5-14, 5-25, 5-26

5S-1 Derive the strain energy per unit volume

$$u = \frac{1}{2E}\left[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\nu(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)\right]$$

5S-2 Derive the strain energy in *volume change* per unit volume

$$u_v = \frac{1-2\nu}{6E}\left[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + 2(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)\right]$$

5S-3 Derive the strain energy in *distortion* per unit volume

$$u_d = \frac{1+\nu}{3E}\left[\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}\right]$$

5S-4 Using *principal axes*, derive *von Mises stress* for yielding

$$\sigma' = \frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]^{1/2} \geq s_y$$

5S-5 Using *non-principal axes* and eigenvalues of the stress matrix at a point in 3D, derive *von Mises stress* for yielding

$$\sigma' = \frac{1}{\sqrt{2}}\left[(\sigma_x-\sigma_y)^2+(\sigma_y-\sigma_z)^2+(\sigma_z-\sigma_x)^2+6(\tau_{xy}^2+\tau_{yz}^2+\tau_{zx}^2)\right]^{1/2}$$

5S-6 Derive the traction vector formula

$$t_i = \sigma_{ji}\, n_j$$

5S-7 Using the traction vector formula, derive the octahedral normal stress

$$\sigma_{\text{oct}} = \frac{1}{3}(\sigma_1+\sigma_2+\sigma_3)$$

5S-8 Using the traction vector formula, derive the octahedral shear stress

$$\tau_{\text{oct}} = \frac{1}{3}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]^{1/2}$$

5S-9 Describe the *octahedral-shear-stress theory* and use it to verify that this theory is equivalent to the *distortion-energy theory*.

5H-1 Let $\sigma' = s_y$ in Eq. (5-13) so that we have a quadratic equation in σ_A and σ_B as follows:

$$\sigma_A^2 - \sigma_A\,\sigma_B + \sigma_B^2 = s_y^2$$

Using matrix algebra and rotation of axis for a symmetric matrix, *identify* and *graph* this quadratic equation. Compare your graph with that in Figure 5-9.