Tutorial 3

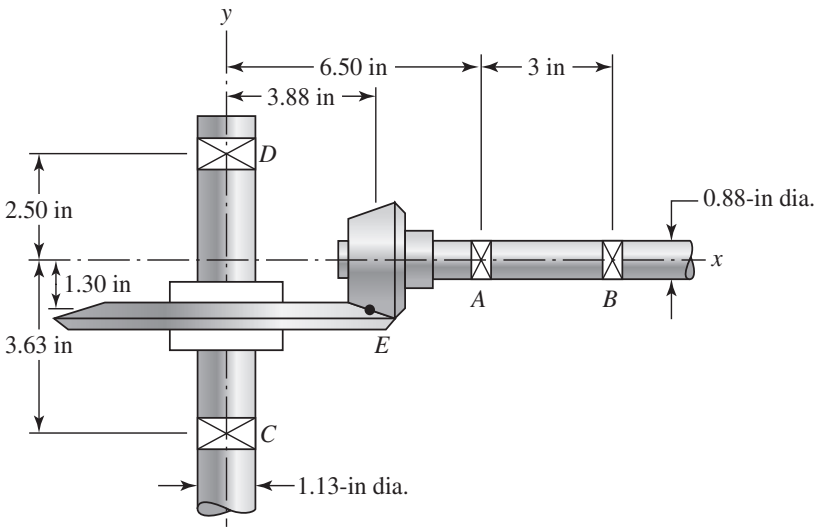
February 1, 2017

ME-30602, 2016-17 Spring Semester

Problem 1:

In the figure (right), the shaft *AB* transmits power to shaft *CD* through a set of bevel gears contacting at point *E*. The contact force at *E* on the gear of shaft *CD* is determined to be

$\boldsymbol{F} = -413\,\boldsymbol{i} - 1614\,\boldsymbol{j} + 3596\,\boldsymbol{k}$ N.



For shaft *CD*:

a) Draw a free-body diagram and determine the reactions at *C* and *D* assuming simple supports (assume also that bearing C carries the thrust load).

b) Draw the shear force and bending moment diagrams.

c) For the critical stress element, determine the torsional shear stress, the bending stress, and the axial stress.

d) For the critical stress element, determine the principal stresses and the maximum shear stress.

Note: 1 in = 25.4 mm

Problem 2: For the initial and final lengths L_0 = 1 m and L_f = 2 m calculate the values of engineering strain, true strain and logarithmic strain in 1D.

Problem 3: The components of the Cauchy stress tensor $\underline{\underline{\sigma}}$ are given in the Cartesian system as

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 3 & -1 \\ 0 & -1 & 3 \end{bmatrix}.$$

(a) Determine the principal stresses and the corresponding principal directions.
(b) Evaluate the three invariants of the stress tensor using the components given above.
(c) Evaluate the three invariants using the principal stress and check that they match with your answer in (b).

Note: The invariants are:

$$I_1 = \text{trace}(\underline{\underline{\sigma}}), \quad I_2 = \frac{1}{2}\left[(\text{trace}(\underline{\underline{\sigma}}))^2 - \text{trace}(\underline{\underline{\sigma}}^2)\right], \quad I_3 = \det(\underline{\underline{\sigma}})$$

Self study:

(a) Equilibrium and free body diagrams
(b) Shear force and bending moment diagrams
(c) Mohr's circle for plane stress
(d) Mohr's circle for 3D state of stress
(e) Bending of beams
(f) Torsion
(g) Buckling of columns