MOOC – "Mechanics of Materials I"
Week Five Quiz

Problem 1) At a point on the surface of a plane stressed object, the strains are measured to be:

$$\varepsilon_x = 800\,\mu\frac{mm}{mm} \qquad \varepsilon_y = -150\,\mu\frac{mm}{mm} \qquad \gamma_{xy} = 500\,\mu rad$$

The object's material properties are:

$$E = 200\ GPa \qquad \nu = 0.25$$

Determine $\sigma_x$, $\sigma_y$, *and* $\tau_{xy}$ at the point.

$$\sigma_x = \frac{E}{1-\nu^2}\left(\epsilon_x + \nu\epsilon_y\right) = \frac{200\ GPA}{1-(0.25)^2}\left(800 + (0.25)(-150)\right)\mu$$

$$\sigma_x = 0.163\ GPa$$ ANS

$$\sigma_y = \frac{E}{1-\nu^2}\left(\epsilon_y + \nu\epsilon_x\right) = \frac{200\ GPa}{1-(0.25)^2}\left(-150 + (0.25)\,800\right)\mu$$

$$\sigma_y = 0.0107\ GPa$$ ANS

$$G = \frac{E}{2(1+\nu)} = \frac{200\ GPa}{2(1+0.25)} = 80$$

$$\tau_{xy} = G\gamma_{xy} = 80\ GPa\,(500\mu)$$

$$\tau_{xy} = 0.0400\ GPa$$ ANS.

Problem 2) A mechanical part is made of structural steel and subject to an uniaxial tensile force of 150 kN. The member has a cross-sectional area of 1300 $mm^2$. The yield stress of the steel is 250 MPa. The ultimate strength of the steel is 450 MPa.
Find the Factor of Safety with respect to yield and the Factor of Safety with respect to fracture.

$$\sigma_{ACTUAL} = \frac{N}{A} = \frac{150}{1300}$$

$$\sigma_{ACTUAL} = 0.115\ GPa = 115\ MPa$$

$$FoS_{YIELD} = \frac{\text{YIELD STRESS}}{\text{ACTUAL STRESS}}$$

$$FOS_{YIELD} = \frac{250\ MPa}{115\ MPa} = \underline{\underline{2.17}}\ ANS$$

$$FoS_{FRACTURE} = \frac{\text{ULTIMATE STRENGTH}}{\text{ACTUAL STRESS}}$$

$$FoS_{FRACTURE} = \frac{450\ MPa}{115\ MPa} = \underline{\underline{3.9}}\ ANS$$

Problem 3) Bar DE is steel and has a cross sectional area of 0.25 $in^2$ and a modulus of elasticity of 29,000 ksi. $\sigma_{steel\ yield}$ = 36 ksi.

Bar BC is brass and has a cross sectional area of 0.3 $in^2$ and a modulus of elasticity of 15,000 ksi. $\sigma_{brass\ yield}$ = 30 ksi.

Bar ABDF can be considered rigid. Both the steel and brass bars are deformable. The weight of the bars can be assumed negligible in comparison to the forces they are supporting.

Find the axial stress in the steel and brass bars, and the deflection at point A