Faculty of Engineering | **Philadelphia University** | Mechanical Eng. Dep.

Mechanics of materials (620213)

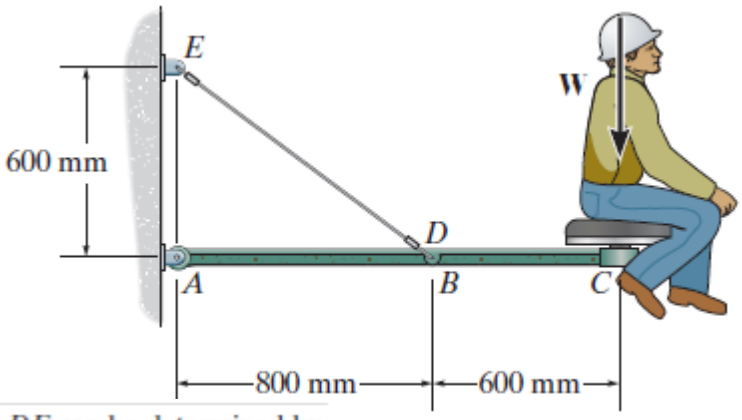
First Exam — **allowed time 50 minutes**

Eng. Laith R. Batarseh — **Sunday 30/3/2014**

Student Name: **Student ID number:**

Problem #1: The wire has a diameter of 5 mm and is made from A-36 steel. If a 80-kg man is sitting on seat *C*, determine the elongation of wire *DE*. (**8marks**)

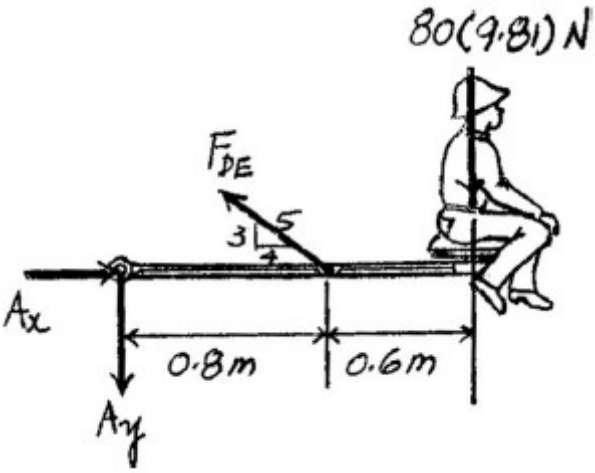
E = 200 GPa σ_y **= 250 MPa**



Equations of Equilibrium: The force developed in wire *DE* can be determined by writing the moment equation of equilibrium about *A* with reference to the free-body diagram shown in Fig. *a*,

$$\zeta + \Sigma M_A = 0; \qquad F_{DE}\left(\frac{3}{5}\right)(0.8) - 80(9.81)(1.4) = 0$$

$$F_{DE} = 2289\ \text{N}$$



Normal Stress and Strain:

$$\sigma_{DE} = \frac{F_{DE}}{A_{DE}} = \frac{2289}{\frac{\pi}{4}(0.005^2)} = 116.58\ \text{MPa}$$

Since $\sigma_{DE} < \sigma_Y$, Hooke's Law can be applied

$$\sigma_{DE} = E\epsilon_{DE}$$

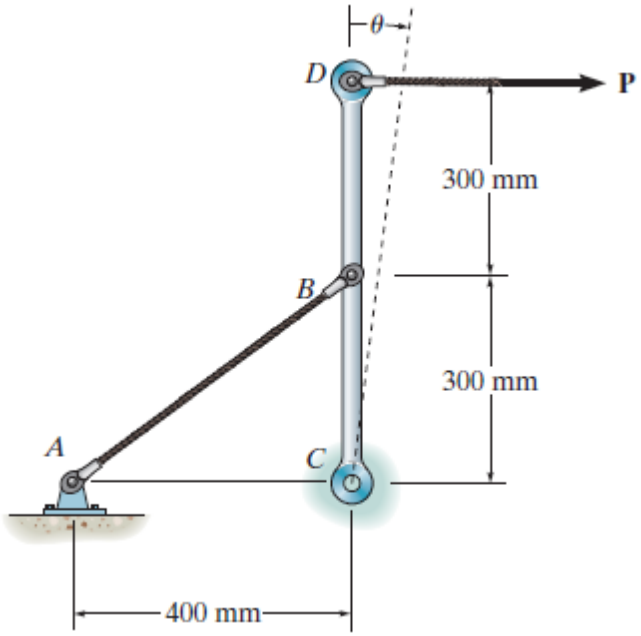
$$116.58(10^6) = 200(10^9)\epsilon_{DE}$$

$$\epsilon_{DE} = 0.5829(10^{-3})\ \text{mm/mm}$$

The unstretched length of wire *DE* is $L_{DE} = \sqrt{600^2 + 800^2} = 1000$ mm. Thus, the elongation of this wire is given by

$$\delta_{DE} = \epsilon_{DE}L_{DE} = 0.5829(10^{-3})(1000) = 0.583\ \text{mm}$$ **Ans.**

Problem #2: Part of a control linkage for an airplane consists of a rigid member *CBD* and a flexible cable *AB*. If a force is applied to the end *D* of the member and causes it to rotate by $\theta = 0.3^{o}$ determine the normal strain in the cable. Originally the cable is un-stretched. **(6marks)**



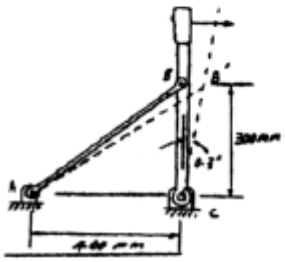
$$AB = \sqrt{400^2 + 300^2} = 500 \text{ mm}$$

$$AB' = \sqrt{400^2 + 300^2 - 2(400)(300)\cos 90.3^\circ}$$

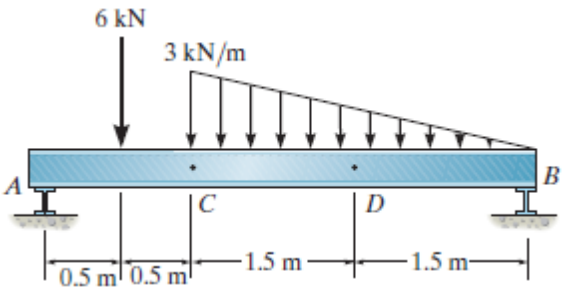
$$= 501.255 \text{ mm}$$

$$\varepsilon_{AB} = \frac{AB' - AB}{AB} = \frac{501.255 - 500}{500}$$

$$= 0.00251 \text{ mm/mm}$$



Problem #3: Determine the resultant internal loadings on the cross section through point *C*. Assume the reactions at the supports *A* and *B* are vertical. **(6marks)**



Referring to the FBD of the entire beam, Fig. *a*,

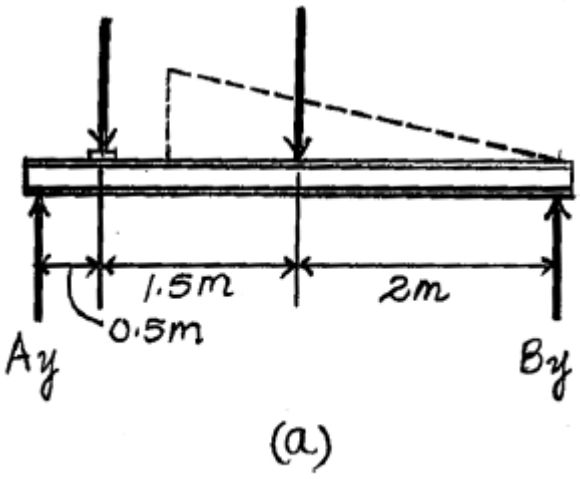
$$\zeta + \Sigma M_B = 0; \quad -A_y(4) + 6(3.5) + \frac{1}{2}(3)(3)(2) = 0 \quad A_y = 7.50\ \text{kN}$$

Referring to the FBD of this segment, Fig. *b*,

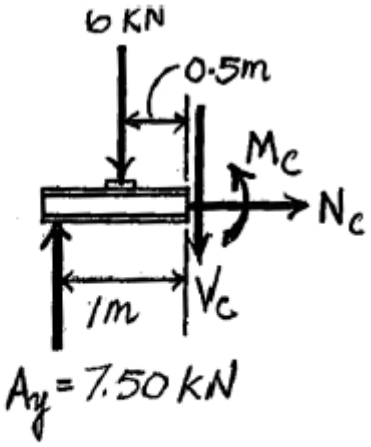
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad N_C = 0 \quad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad 7.50 - 6 - V_C = 0 \quad V_C = 1.50\ \text{kN} \quad \textbf{Ans.}$$

$$\zeta + \Sigma M_C = 0; \quad M_C + 6(0.5) - 7.5(1) = 0 \quad M_C = 4.50\ \text{kN}\cdot\text{m} \quad \textbf{Ans.}$$

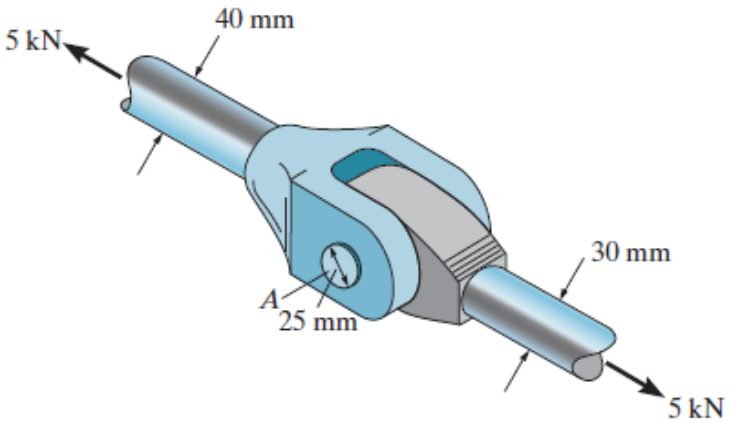


(a)



(b)

Problem #4: The yoke-and-rod connection is subjected to a tensile force of 5 kN. Determine the average normal stress in each rod and the average shear stress in the pin *A* between the members. **(Bonus 2marks)**



For the 40 – mm – dia rod:

$$\sigma_{40} = \frac{P}{A} = \frac{5\,(10^3)}{\frac{\pi}{4}(0.04)^2} = 3.98\ \text{MPa}$$

For the 30 – mm – dia rod:

$$\sigma_{30} = \frac{V}{A} = \frac{5\,(10^3)}{\frac{\pi}{4}(0.03)^2} = 7.07\ \text{MPa}$$

Average shear stress for pin *A*:

$$\tau_{\text{avg}} = \frac{P}{A} = \frac{2.5\,(10^3)}{\frac{\pi}{4}(0.025)^2} = 5.09\ \text{MPa}$$