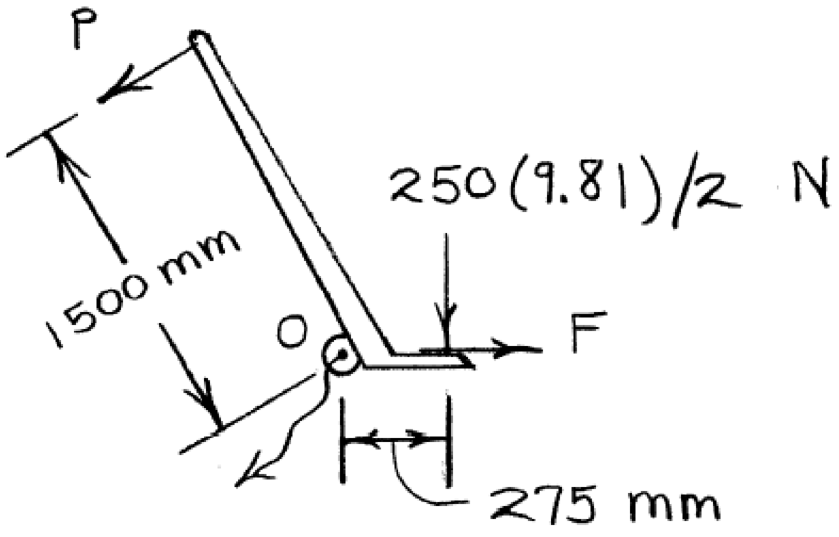
ENGINEERING MECHANICS (ME101) – ANSWERS TO TUTORIAL 2
DATE OF TUTORIAL – 17 Jan 2020.

A1.



$$\circlearrowleft + \sum M_o = 0: \quad P(1500) - \tfrac{1}{2}(250)(9.81)(275) = 0$$

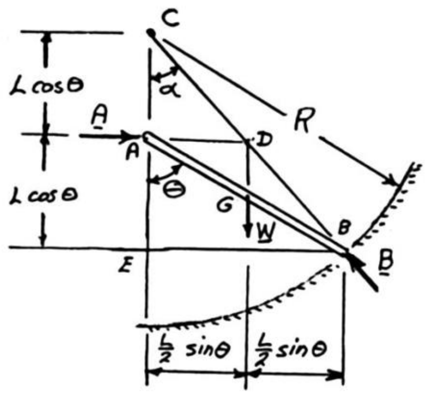
$$\underline{P = 225 \text{ N}}$$

(assumes that the moment of the friction force F is small compared to the other moments)

A2.

SOLUTION

Free-Body Diagram (Three-force body)



Reaction **B** must pass through D where **B** and **W** intersect.

Note that ΔABC and ΔBGD are similar.

$$AC = AE = L\cos\theta$$

In ΔABC:

$$(CE)^2 + (BE)^2 = (BC)^2$$

$$(2L\cos\theta)^2 + (L\sin\theta)^2 = R^2$$

$$\left(\frac{R}{L}\right)^2 = 4\cos^2\theta + \sin^2\theta$$

$$\left(\frac{R}{L}\right)^2 = 4\cos^2\theta + 1 - \cos^2\theta$$

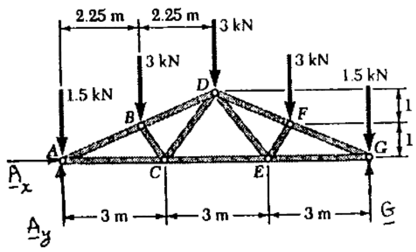
$$\left(\frac{R}{L}\right)^2 = 3\cos^2\theta + 1$$

$$\cos^2\theta = \frac{1}{3}\left[\left(\frac{R}{L}\right)^2 - 1\right] \blacktriangleleft$$

A3.

SOLUTION

Free body: Truss:



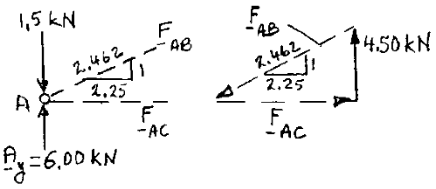
$$\Sigma F_x = 0: \quad \mathbf{A}_x = 0$$

Because of the symmetry of the truss and loading,

$$\mathbf{A}_y = \mathbf{G} = \frac{1}{2} \text{ total load}$$

$$\mathbf{A}_y = \mathbf{G} = 6.00 \text{ kN} \uparrow$$

Free body: Joint A:

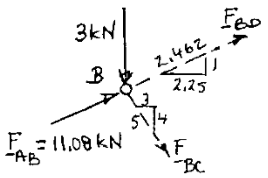


$$\frac{F_{AB}}{2.462} = \frac{F_{AC}}{2.25} = \frac{4.50 \text{ kN}}{1}$$

$F_{AB} = 11.08 \text{ kN} \quad C$ ◀

$F_{AC} = 10.125 \text{ kN}$ $\qquad$ $F_{AC} = 10.13 \text{ kN} \quad T$ ◀

Free body: Joint B:



$$\overset{+}{\rightarrow} \Sigma F_x = 0: \quad \frac{3}{5}F_{BC} + \frac{2.25}{2.462}F_{BD} + \frac{2.25}{2.462}(11.08 \text{ kN}) = 0 \qquad (1)$$

$$+\uparrow \Sigma F_y = 0: \quad -\frac{4}{5}F_{BC} + \frac{F_{BD}}{2.462} + \frac{11.08 \text{ kN}}{2.462} - 3 \text{ kN} = 0 \qquad (2)$$

Multiply Eq. (2) by –2.25 and add to Eq. (1):

$$\frac{12}{5}F_{BC} + 6.75 \text{ kN} = 0 \qquad F_{BC} = -2.8125$$

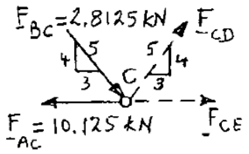
$F_{BC} = 2.81 \text{ kN} \quad C$ ◀

Multiply Eq. (1) by 4, Eq. (2) by 3, and add:

$$\frac{12}{2.462}F_{BD} + \frac{12}{2.462}(11.08 \text{ kN}) - 9 \text{ kN} = 0$$

$F_{BD} = -9.2335 \text{ kN}$ $\qquad$ $F_{BD} = 9.23 \text{ kN} \quad C$ ◀

Free body: Joint C:



$$+\uparrow \Sigma F_y = 0: \quad \frac{4}{5}F_{CD} - \frac{4}{5}(2.8125 \text{ kN}) = 0$$

$F_{CD} = 2.8125 \text{ kN},$ $\qquad$ $F_{CD} = 2.81 \text{ kN} \quad T$ ◀

$$\overset{+}{\rightarrow} \Sigma F_x = 0: \quad F_{CE} - 10.125 \text{ kN} + \frac{3}{5}(2.8125 \text{ kN}) + \frac{3}{5}(2.8125 \text{ kN}) = 0$$

$F_{CE} = +6.7500 \text{ kN}$ $\qquad$ $F_{CE} = 6.75 \text{ kN} \quad T$ ◀

Because of the symmetry of the truss and loading, we deduce that

$F_{DE} = F_{CD}$ $\qquad$ $F_{CD} = 2.81 \text{ kN} \quad T$ ◀

$F_{DF} = F_{BD}$ $\qquad$ $F_{DF} = 9.23 \text{ kN} \quad C$ ◀

$F_{EF} = F_{BC}$ $\qquad$ $F_{EF} = 2.81 \text{ kN} \quad C$ ◀

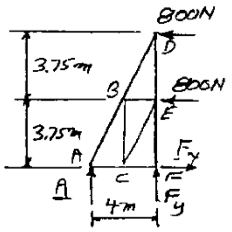
$F_{EG} = F_{AC}$ $\qquad$ $F_{EG} = 10.13 \text{ kN} \quad T$ ◀

$F_{FG} = F_{AB}$ $\qquad$ $F_{FG} = 11.08 \text{ kN} \quad C$ ◀

A4.

SOLUTION

Free body: Entire truss:



$$\circlearrowleft+\ \Sigma M_F = 0: \quad (800\text{ N})(7.5\text{ m}) + (800\text{ N})(3.75\text{ m}) - A(2\text{ m}) = 0$$

$$A = +2250\text{ N} \qquad \mathbf{A} = 2250\text{ N}\uparrow$$

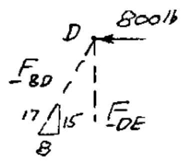
$$+\uparrow \Sigma F_y = 0: \quad 2250\text{ N} + F_y = 0$$

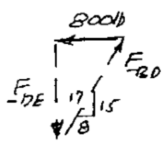
$$F_y = -2250\text{ N} \quad \mathbf{F}_y = 2250\text{ N}\downarrow$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad -800\text{ N} - 800\text{ N} + F_x = 0$$

$$F_x = +1600\text{ N} \quad \mathbf{F}_x = 1600\text{ N}\longrightarrow$$

Joint *D*:



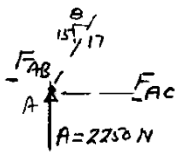


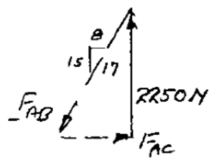
$$\frac{800\text{ N}}{8} = \frac{F_{DE}}{15} = \frac{F_{BD}}{17}$$

$F_{BD} = 1700\text{ N} \quad C$ ◀

$F_{DE} = 1500\text{ N} \quad T$ ◀

Joint *A*:



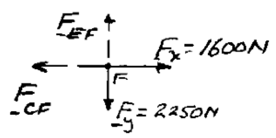


$$\frac{2250\text{ N}}{15} = \frac{F_{AB}}{17} = \frac{F_{AC}}{8}$$

$F_{AB} = 2250\text{ N} \quad C$ ◀

$F_{AC} = 1200\text{ N} \quad T$ ◀

Joint *F*:



$$\xrightarrow{+} \Sigma F_x = 0: \quad 1600\text{ N} - F_{CF} = 0$$

$$F_{CF} = +1600\text{ N}$$

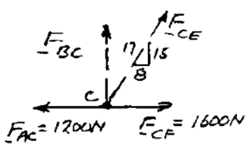
$F_{CF} = 1600\text{ N} \quad T$ ◀

$$+\uparrow \Sigma F_y = 0: \quad F_{EF} - 2250\text{ N} = 0$$

$$F_{EF} = +2250\text{ N}$$

$F_{EF} = 2250\text{ N} \quad T$ ◀

Joint *C*:



$$\xrightarrow{+} \Sigma F_x = 0: \quad \frac{8}{17}F_{CE} - 1200\text{ N} + 1600\text{ N} = 0$$

$$F_{CE} = -850\text{ N}$$

$F_{CE} = 850\text{ N} \quad C$ ◀

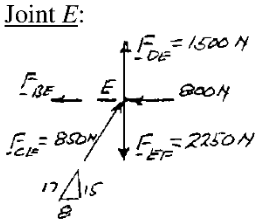
$$+\uparrow \Sigma F_y = 0: \quad F_{BC} + \frac{15}{17}F_{CE} = 0$$

$$F_{BC} = -\frac{15}{17}F_{CE} = -\frac{15}{17}(-850\text{ N})$$

$$F_{BC} = +750\text{ N}$$

$F_{BC} = 750\text{ N} \quad T$ ◀

Joint *E*:



$$\xrightarrow{+} \Sigma F_x = 0: \quad -F_{BE} - 800\text{ N} + \frac{8}{17}(850\text{ N}) = 0$$

$$F_{BE} = -400\text{ N}$$

$F_{BE} = 400\text{ N} \quad C$ ◀

$$+\uparrow \Sigma F_y = 0: \quad 1500\text{ N} - 2250\text{ N} + \frac{15}{17}(850\text{ N}) = 0$$

$$0 = 0 \quad \text{(checks)}$$