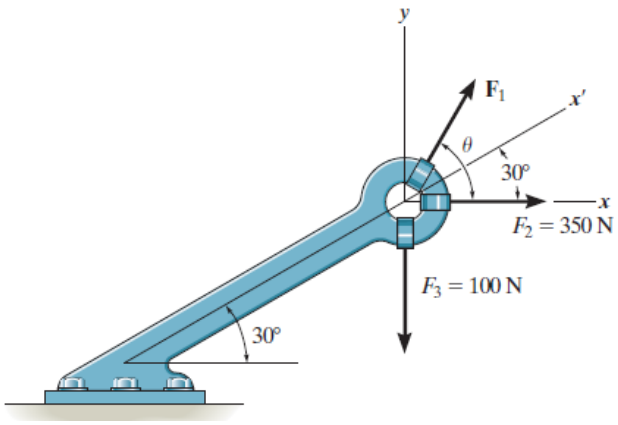
Model answer of summer course final exam Aug., 18, 2013

Question 1:

1. Express each of the three forces acting on the bracket in Cartesian vector form with respect to the x and y axes. Determine the magnitude and direction Θ of F_1 so that the resultant force is directed to the positive x' axis and has a magnitude of $F_R = 600$ N.



Solution

$\mathbf{F}_1 = \{F_1 \cos\theta\,\mathbf{i} + F_1 \sin\theta\,\mathbf{j}\}$ N **Ans**

$\mathbf{F}_2 = \{350\mathbf{i}\}$ N **Ans**

$\mathbf{F}_3 = \{-100\mathbf{j}\}$ N **Ans**

Require,

$\mathbf{F}_R = 600\cos 30°\,\mathbf{i} + 600\sin 30°\,\mathbf{j}$

$\mathbf{F}_R = \{519.6\mathbf{i} + 300\mathbf{j}\}$ N

$\mathbf{F}_R = \Sigma\mathbf{F}$

Equating the i and j components yields :

$519.6 = F_1 \cos\theta + 350$

$F_1 \cos\theta = 169.6$

$300 = F_1 \sin\theta - 100$

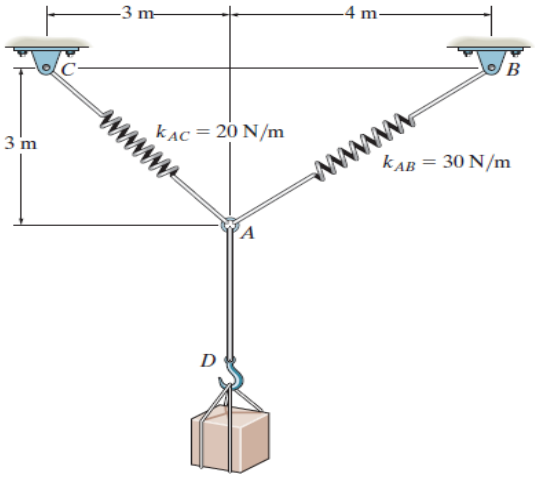
$F_1 \sin\theta = 400$

$\theta = \tan^{-1}\left[\frac{400}{169.6}\right] = 67.0°$ **Ans**

$F_1 = 434$ N **Ans**

Question 2:

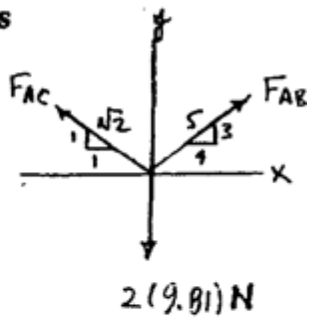
2. Determine the stretch in springs AC and AB for equilibrium of the 2-kg block. The springs are shown in the equilibrium position.



Solution

$$F_{AD} = 2(9.81) = x_{AD}(40)$$

$$x_{AD} = 0.4905 \text{ m}$$ **Ans**



$$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad F_{AB}\left(\frac{4}{5}\right) - F_{AC}\left(\frac{1}{\sqrt{2}}\right) = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad F_{AC}\left(\frac{1}{\sqrt{2}}\right) + F_{AB}\left(\frac{3}{5}\right) - 2(9.81) = 0$$

$$F_{AC} = 15.86 \text{ N}$$

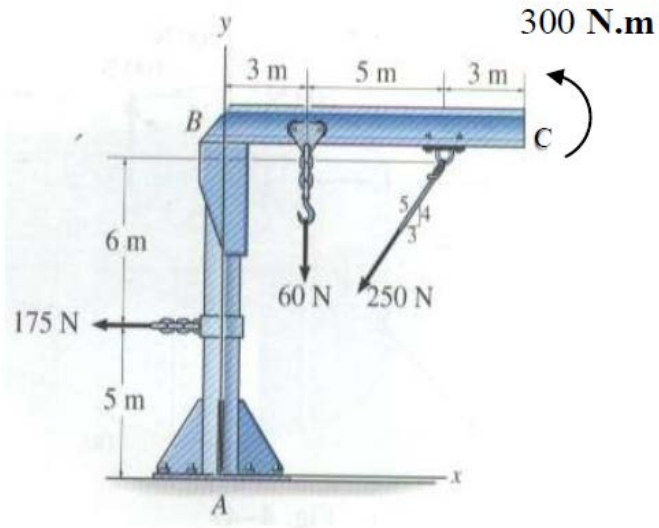
$$x_{AC} = \frac{15.86}{20} = 0.793 \text{ m}$$ **Ans**

$$F_{AB} = 14.01 \text{ N}$$

$$x_{AB} = \frac{14.01}{30} = 0.467 \text{ m}$$ **Ans**

Question 3:

3. The jib crane is subjected to three coplanar forces and a moment. Replace this loading by an equivalent resultant force and specify where the resultant's line of action intersects the boom BC measured from B.



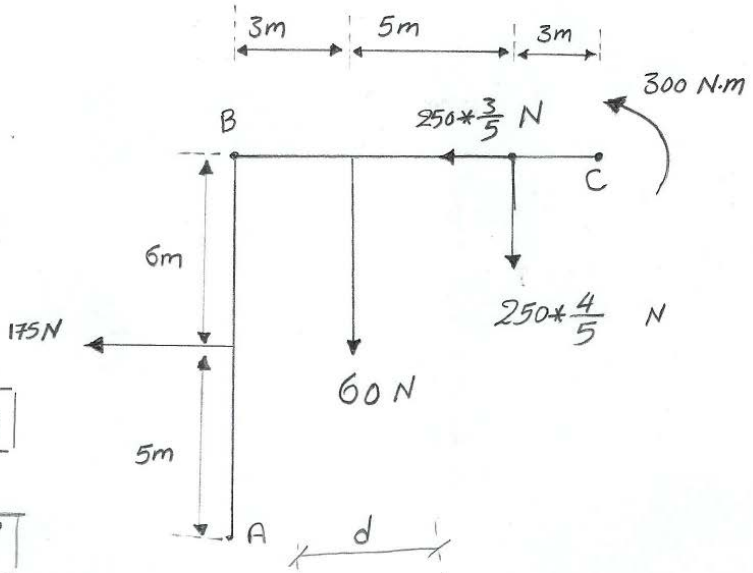
Solution

$F_{R_x} = -175 - 250 * \frac{3}{5} = -325\ N$

$F_{R_y} = -60 - 250 * \frac{4}{5} = -260\ N$

$\therefore F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2} = \boxed{416.2\ N}$

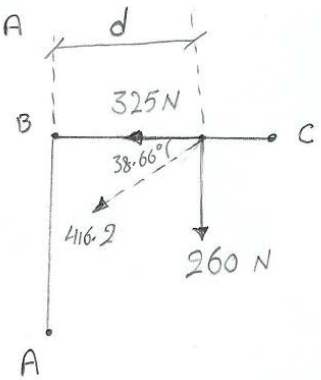
$\theta = \tan^{-1}\left|\frac{260}{325}\right| = \boxed{38.66^\circ}$



$\left(+\right) M_{R_B} = \Sigma M_B$

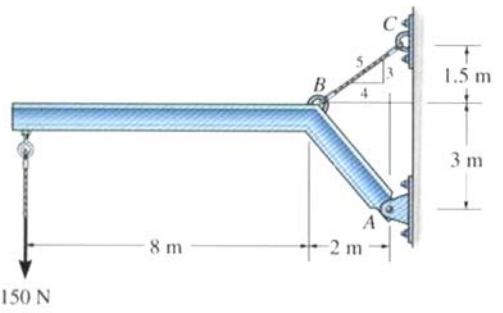
$-260 * d = -175 * 6 - 60 * 3 - 200 * 8 + 300$

$\therefore \boxed{d = 9.73\ m}$



Question 4:

4. A force of 150 N acts on the end of the beam. Determine the magnitude and direction of the reaction at the pin A and the tension in the cable BC



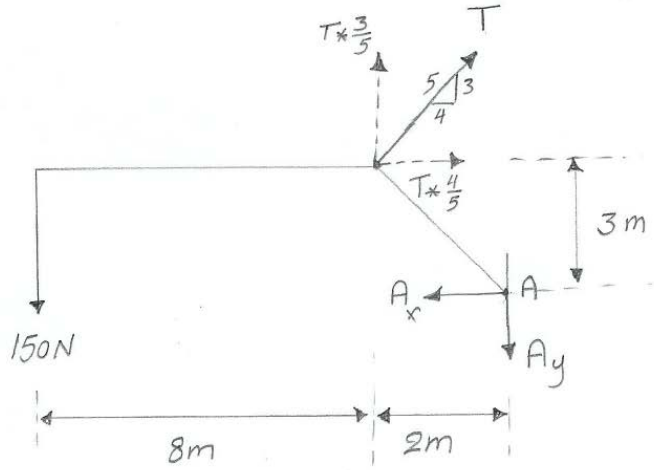
Solution

$\Sigma M_A = 0 \; +)$

$150*10 - T*\frac{4}{5}*3 - T*\frac{3}{5}*2 = 0$

$\Rightarrow 1500 - T\left(\frac{12}{5}+\frac{6}{5}\right) = 0$

$\therefore \boxed{T = 416.67 \text{ N}}$



$\Sigma F_x = 0 \quad \xrightarrow{+}$

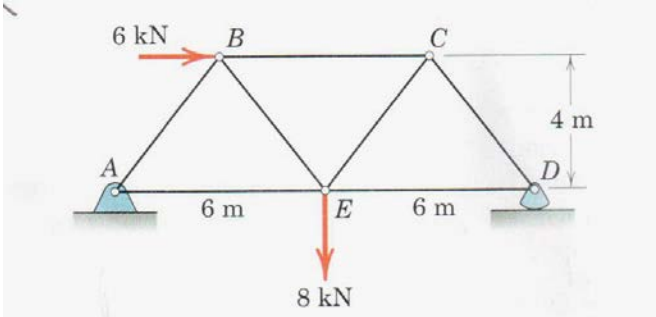
$416.67*\frac{4}{5} - A_x = 0 \Rightarrow \boxed{A_x = 333.33 \text{ N}}$

$\Sigma F_y = 0 \; +\uparrow$

$-150 + 416.67*\frac{3}{5} - A_y = 0 \Rightarrow \boxed{A_y = 100 \text{ N}}$

Question 5:

5. Calculate the force in each member of the loaded truss. Specify whether the members are in tension or in compression

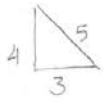


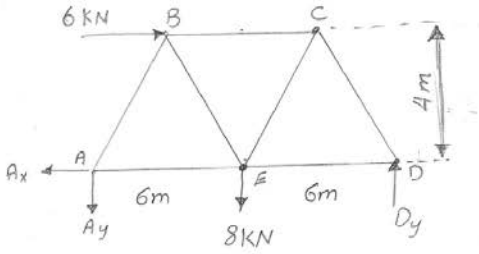
Solution

$\Sigma M_A = 0 \; +)$

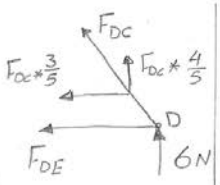
$-6*4 - 8*6 + D_y*12 = 0$

$\therefore D_y = 6\ N$





∴ Joint D :



$\Sigma F_y = 0$

$6 + F_{DC}*\frac{4}{5} = 0$

$\therefore F_{DC} = -7.5\ KN$

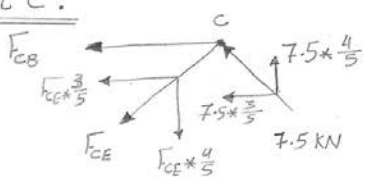
$\Rightarrow \boxed{F_{DC} = 7.5\ KN\ (C)}$

$\Sigma F_x = 0$

$-F_{DE} - (-7.5*\frac{3}{5}) = 0$

$\Rightarrow \boxed{F_{DE} = 4.5\ KN\ (T)}$

Joint C :



$\Sigma F_x = 0$

$-F_{CB} - F_{CE}*\frac{3}{5} - 7.5*\frac{3}{5} = 0$

$\therefore F_{CB} = -4.5 - F_{CE}*\frac{3}{5}$

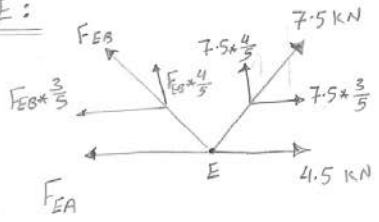
$\Sigma F_y = 0$

$7.5*\frac{4}{5} - F_{CE}*\frac{4}{5} = 0$

$\therefore \boxed{F_{CE} = 7.5\ KN\ (T)}$

$\therefore \boxed{F_{CB} = 9\ KN\ (C)}$

Joint E :



$\Sigma F_y = 0$

$7.5*\frac{4}{5} + F_{EB}*\frac{4}{5} = 0$

$\therefore F_{EB} = -7.5\ KN$

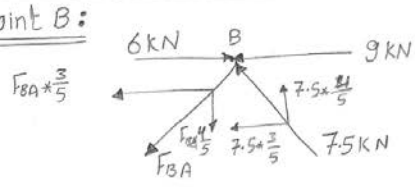
$\boxed{F_{EB} = 7.5\ KN\ (C)}$

$\Sigma F_x = 0$

$4.5 + 7.5*\frac{3}{5} - (-7.5*\frac{3}{5}) - F_{EA} = 0$

$\therefore \boxed{F_{EA} = 13.5\ KN\ (T)}$

Joint B :



$\Sigma F_y = 0$

$7.5*\frac{4}{5} - F_{BA}*\frac{4}{5} = 0$

$\therefore \boxed{F_{BA} = 7.5\ KN\ (T)}$