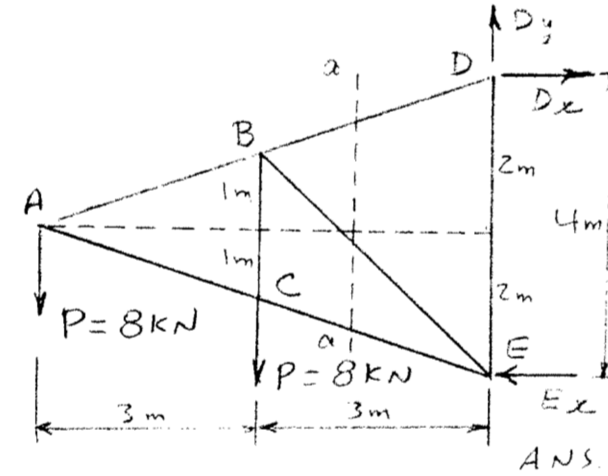
1. FBD - Entire truss

a) $+\uparrow \Sigma F_y = 0$

$D_y - 8\,kN - 8\,kN = 0$

$\therefore D_y = \underline{\underline{16\,kN\uparrow}}$ ANS.



$\curvearrowleft + \Sigma M_D = 0$

$8\,kN \times 6m + 8\,kN \times 3m - E_x \times 4m = 0$

$48 + 24 = 4E_x$

$\therefore E_x = \frac{72}{4} = \underline{\underline{18\,kN}} \leftarrow$

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

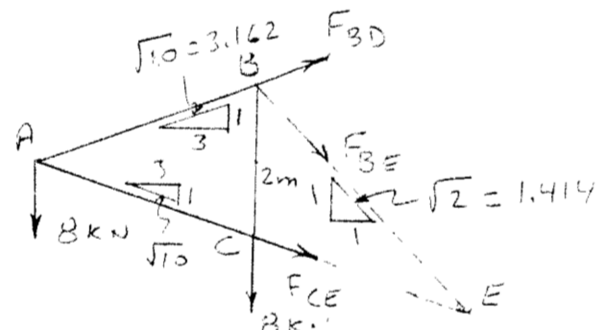
$D_x - E_x = 0;\ \therefore D_x = E_x = \underline{18\,kN} \rightarrow$ ANS.

$\therefore D = \sqrt{(16)^2 + (18)^2} = 24.08\,kN;\ \angle\theta = \tan^{-1}\frac{18}{12} = \underline{48.366^\circ}$

$\therefore D = \underline{\underline{24.08\,kN}}$ $\angle 48.366^\circ$ ANS.

b) FBD - Left side of section a-a.

$\curvearrowleft + \Sigma M_A = 0$



$-8\,kN \times 3m - F_{BE} \times \frac{1}{1.414} \times 3m$

$- F_{BE} \times \frac{1}{1.414} \times 1m = 0$

$-24 - 2.122 F_{BE} - 0.707 F_{BE} = 0$

$2.829 F_{BE} = -24;\ \therefore F_{BE} = \frac{-24}{2.829} = \underline{\underline{8.484\,kN\ (C)}}$ ANS.

$\curvearrowleft + \Sigma M_E = 0$

$8\,kN \times 3m + 8\,kN \times 6m - F_{BD} \times \frac{1}{3.162} \times 3m - F_{BD} \times \frac{3}{3.162} \times 3m = 0$

$24 + 48 - 0.949 F_{BD} - 2.846 F_{BD} = 0$

$3.795 F_{BD} = 72,\ \therefore F_{BD} = 18.972\,kN\ (T)$ ANS.

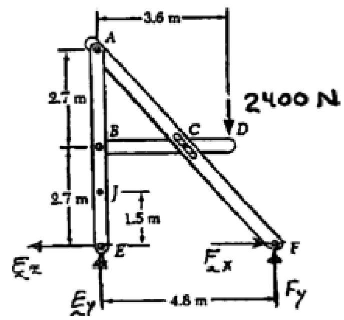
1. Cont'd

$\curvearrowleft + \Sigma M_B = 0$

$8\,kN \times 3m + F_{CE} \times \frac{3}{3.162} \times 2m = 0$

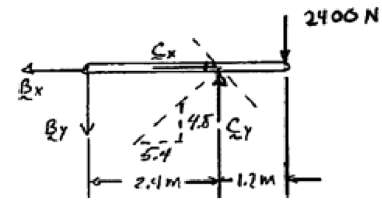
$1.898 F_{CE} = -24$ $\therefore F_{CE} = -\frac{24}{1.898} = \underline{\underline{-12.645\,kN\ (C)}}$ ANS.

FBD Frame:



$$(+\Sigma M_F = 0: \quad (1.2\text{ m})(2400\text{ N}) - (4.8\text{ m})E_y = 0 \qquad \mathbf{E}_y = 600\text{ N}\uparrow \blacktriangleleft$$

FBD member *BC*:



$$C_y = \frac{4.8}{5.4}C_x = \frac{8}{9}C_x$$

$$(+\Sigma M_C = 0: \quad (2.4\text{ m})B_y - (1.2\text{ m})(2400\text{ N}) = 0 \quad B_y = 1200\text{ N}\downarrow$$

On *ABE*: $\mathbf{B}_y = 1200\text{ N}\uparrow \blacktriangleleft$

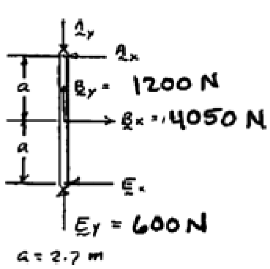
$$+\uparrow \Sigma F_y = 0: \quad -1200\text{ N} + C_y - 2400\text{ N} = 0 \quad C_y = 3600\text{ N}\uparrow$$

so $$C_x = \frac{9}{8}C_y \quad C_x = 4050\text{ N}\longrightarrow$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad -B_x + C_x = 0 \quad B_x = 4050\text{ N}\longleftarrow \text{ on } BC$$

On *ABE*: $\mathbf{B}_x = 4050\text{ N}\longrightarrow \blacktriangleleft$

FBD member *AB0E*:



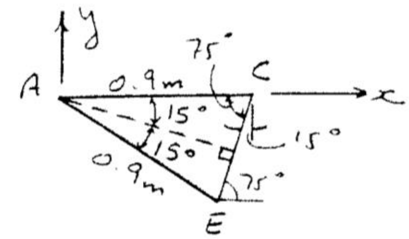
$$(+\Sigma M_A = 0: \quad a(4050\text{ N}) - 2aE_x = 0$$

$$E_x = 2025\text{ N} \qquad \mathbf{E}_x = 2025\text{ N}\longleftarrow \blacktriangleleft$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad -A_x + (4050 - 2025)\text{ N} = 0 \qquad \mathbf{A}_x = 2025\text{ N}\longleftarrow \blacktriangleleft$$

$$+\uparrow \Sigma F_y = 0: \quad 600\text{ N} + 1200\text{ N} - A_y = 0 \qquad \mathbf{A}_y = 1800\text{ N}\downarrow \blacktriangleleft$$

3. a) FBD _ Cover

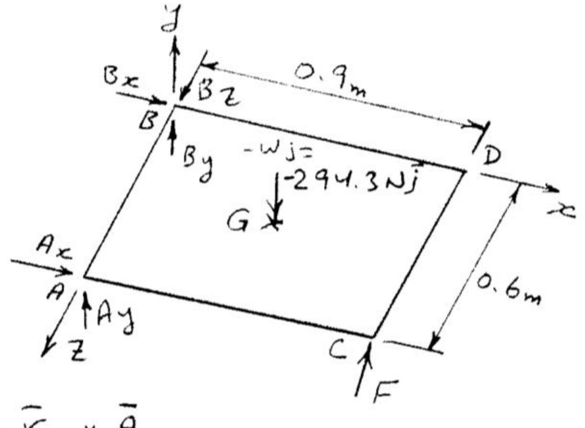


Force exerted by CE:

AC = AE. Assume $\bar{F}_{CE} = \bar{F}$

$$\bar{F} = F(\sin 75°)\,\bar{i} + F(\cos 75°)\,\bar{j}$$

$$\bar{F} = F\,(0.2588\,\bar{i} + 0.9659\,\bar{j})$$



$$W = mg = 30\,\text{kg} \times 9.81\,\text{m/s}^2 = 294.3\,\text{N}$$

$$\Sigma \bar{M}_B = 0$$

$$\bar{r}_{A/B} = 0.6\,\bar{k}\ ; \quad \bar{r}_{C/B} = 0.9\,\bar{i} + 0.6\,\bar{k}$$

$$\bar{r}_{G/B} = 0.45\,\bar{i} + 0.3\,\bar{k}$$

b)

$$\therefore\ \Sigma M_B = 0 = \bar{r}_{G/B} \times (-294.3\,\bar{j}) + \bar{r}_{C/B} \times \bar{F} + \bar{r}_{A/B} \times \bar{A}$$

i.e. $(0.45\,\bar{i} + 0.3\,\bar{k}) \times (-294.3\,\bar{j}) + (0.9\,\bar{i} + 0.6\,\bar{k}) \times (0.2588\,\bar{i} + 0.9659\,\bar{j})F$
$+\ 0.6\,\bar{k}\,(A_x\,\bar{i} + A_y\,\bar{j}) = 0$

$$-132.435\,\bar{k} + 88.29\,\bar{i} + 0.869F\,\bar{k} + 0.153F\,\bar{j} - 0.579F\,\bar{i}$$
$$+\ 0.6A_x\,\bar{j} - 0.6A_y\,\bar{i} = 0$$

$\bar{k}\ \ \bar{j}\ \ \bar{i}$

or

$$\begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ 0.45 & 0 & 0.3 \\ 0 & -294.3 & 0 \end{vmatrix} + \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ 0.9 & 0 & 0.6 \\ 0.2588 & 0.9659 & 0 \end{vmatrix} F + \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ 0 & 0 & 0.6 \\ A_x & A_y & 0 \end{vmatrix} = 0$$

Coeff of $\bar{i}$: $88.29 - 0.579F - 0.6A_y = 0$ ——— (1)

Coeff of $\bar{j}$: $0.153F + 0.6A_x = 0$ ——— (2)

Coeff of $\bar{k}$: $-132.435 + 0.869F = 0$; $\therefore F = \underline{\underline{152.4\,\text{N}}}$ ANS.

Insert in (1): $88.29 - 0.579 \times 152.4 - 0.6A_y = 0$

$0.6A_y = 88.29 - 88.23$

$0.6A_y = 0.06$, $\therefore A_y = \underline{\underline{0.1\,\text{N} = 0}}$ ANS.

Insert in (2): $0.153 \times 152.4 + 0.6A_x = 0$

$0.6A_x = -23.317$, $\therefore A_x = \underline{\underline{-38.86\,\text{N}}}$ ANS.

$$\Sigma \bar{F} = \bar{A} + \bar{B} + \bar{F} - W\bar{j} = 0$$

Coeff. of $\bar{i}$: $\quad A_x + B_x + 152.4 \times 0.2588 = 0$

$$-38.8 + B_x + 39.44 = 0,$$

$$\therefore B_x = \underline{\underline{-0.64\text{ N} = 0}} \qquad \text{ANS.}$$

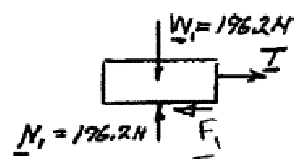
Coeff. of $\bar{j}$: $\quad A_y + B_y + 0.9659 \times 152.4 - 294.3 = 0$

$$0 + B_y + 147.20 - 294.3 = 0$$

$$\therefore B_y = \underline{\underline{147.2\text{ N}}} \qquad \text{ANS.}$$

Coeff. of $\bar{k}$: $\quad B_z = \underline{\underline{0}} \qquad \text{ANS.}$

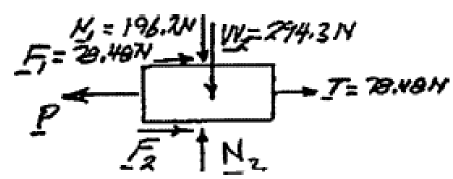
Free body: 20-kg block



$$W_1 = (20\text{ kg})(9.81\text{ m/s}^2) = 196.2\text{ N}$$
$$F_1 = \mu_s N_1 = 0.4(196.2\text{ N}) = 78.48\text{ N}$$

$$\xrightarrow{+} \Sigma F = 0: \quad T - F_1 = 0 \quad T = F_1 = 78.48\text{ N}$$

Free body: 30-kg block



$$W_2 = (30\text{ kg})(9.81\text{ m/s}^2) = 294.3\text{ N}$$
$$N_2 = 196.2\text{ N} + 294.3\text{ N} = 490.5\text{ N}$$
$$F_2 = \mu_s N_2 = 0.4(490.5\text{ N}) = 196.2\text{ N}$$

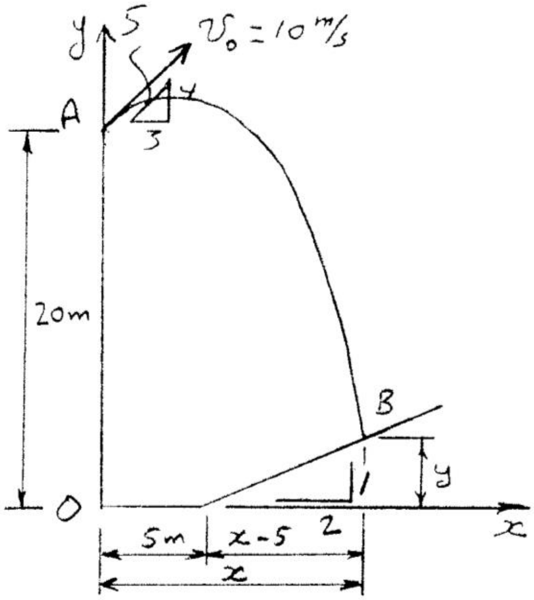
$$\xleftarrow{+} \Sigma F = 0: \quad P - F_1 - F_2 - T = 0$$

$$P = 78.48\text{ N} + 196.2\text{ N} + 78.48\text{ N} = 353.2\text{ N}$$

$$\mathbf{P} = 353\text{ N} \longleftarrow \blacktriangleleft$$

5. a)

Assume, the ball hits the slope at B whose coordinates are x & y.



$(v_0)_x = 10\,m/s \times \frac{3}{5} = 6\,m/s$

$(v_0)_y = 10\,m/s \times \frac{4}{5} = 8\,m/s$

*- Horizontal Motion

$x = x_0 + (v_0)_x t = 0 + 6\,m/s\, t$

$\therefore x = 6t\ m$ ——— (1)

*- Vertical Motion

$y = y_0 + (v_0)_y t - \frac{1}{2} \times 9.81 t^2$

$y = 20_m + 8t - \frac{1}{2} \times 9.81 t^2$ ——— (2)

From the diagram: $\frac{y}{x-5} = \frac{1}{2}$; $\therefore y = \frac{x}{2} - \frac{5}{2}$ — (3). Insert in (2):

$\therefore \frac{x}{2} - \frac{5}{2} = 20 + 8t - \frac{1}{2} \times 9.81 t^2$

i.e. $x - 5 = 40 + 16t - 9.81 t^2$

Insert $x = 6t$ from (1):

$\therefore 6t - 5 = 40 + 16t - 9.81 t^2$

$9.81 t^2 - 10t - 45 = 0$

$\therefore t = 2.71$ sec. $\left(t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \right)$

Another value of $t = -1.68\,s$ is rejected since it is -ve.

Insert in (1): $x = 6 \times 2.71 = \underline{\underline{16.26\ m}}$ ANS.

Insert in (3): $y = \frac{16.26}{2} - \frac{5}{2} = \underline{\underline{5.63\,m}}$ ANS.

b) At point B: $v_x = (v_0)_x = 6\,m/s$

$v_y = (v_0)_y - gt = 8\,m/s - 9.81 \times 2.71 = -18.6\,m/s$

$\therefore v_B = \sqrt{(6)^2 + (-18.6)^2} = \underline{\underline{17.6\,m/s}}$ ANS.

END