SOLUTIONS

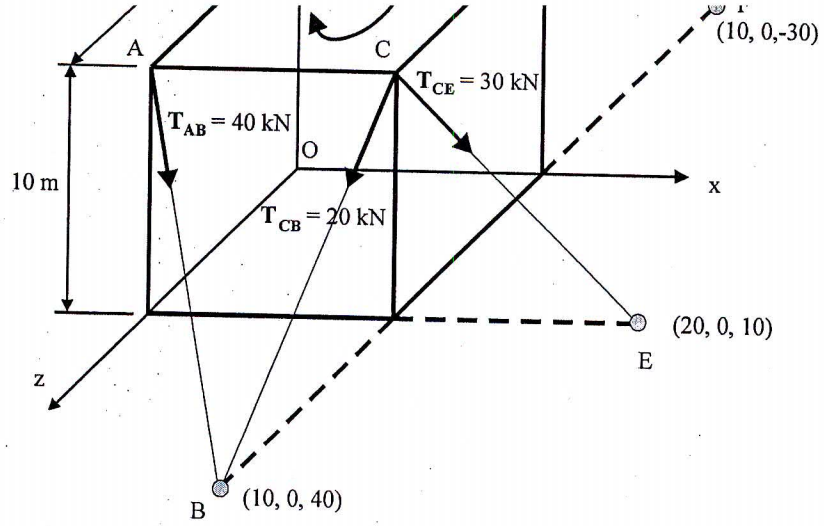


Figure 1

$$\vec{T}_{AB} = T_{AB}\vec{\lambda}_{AB} = 40\vec{\lambda}_{AB}$$

$$\vec{\lambda}_{AB} = \frac{\vec{AB}}{AB} \qquad \vec{AB} = 10\hat{i} - 10\hat{j} + 30\hat{k}$$

$$AB = \sqrt{(10)^2 + (-10)^2 + (30)^2} = \sqrt{1100}$$

$$\vec{T}_{AB} = \frac{40(10\hat{i} - 10\hat{j} + 30\hat{k})}{\sqrt{1100}} = (12.06\hat{i} - 12.06\hat{j} + 36.18\hat{k})\ kN$$

$$\vec{T}_{CB} = T_{CB}\vec{\lambda}_{CB} = 20\vec{\lambda}_{CB}$$

$$\vec{\lambda}_{CB} = \frac{\vec{CB}}{CB} \qquad \vec{CB} = 0\hat{i} - 10\hat{j} + 30\hat{k}$$

$$CB = \sqrt{(-10)^2 + (30)^2} = \sqrt{1000}$$

$$\vec{T}_{CB} = \frac{20(0\hat{i} - 10\hat{j} + 30\hat{k})}{\sqrt{1000}} = (-6.32\hat{j} + 18.97\hat{k})\ kN$$

$$\vec{T}_{CE} = T_{CE}\vec{\lambda}_{CE} = 30\vec{\lambda}_{CE}$$

$$\vec{\lambda}_{CE} = \frac{\vec{CE}}{CE} \qquad \vec{CE} = 10\hat{i} - 10\hat{j} + 0\hat{k} \qquad CE = \sqrt{10^2 + (-10)^2} = \sqrt{200}$$

$$\vec{T}_{CE} = \frac{30(10\hat{i} - 10\hat{j} + 0\hat{k})}{\sqrt{200}} = (21.21\hat{i} - 21.21\hat{j})\ kN$$

M_{RA} =

i	j	k	i	j
10	0	0	10	0
0	-6.32	+18.97	0	-6.32

$= [-63.2\hat{k}] - [189.7\hat{j}]$

$= (-189.7\hat{j} - 63.2\hat{k})$ kN.m

+

i	j	k	i	j
10	0	0	10	0
21.21	-21.21	0	21.21	-21.21

$= [-212.1\hat{k}] - [0]$

$= (-212.1\hat{k})$ kN.m

+

i	j	k	i	j
10	0	-10	10	0
0	-15.81	-47.43	0	-15.81

$= [-158.1\hat{k}] - [158.1\hat{i} - 474.3\hat{j}]$

$= (-158.1\hat{i} + 474.3\hat{j} - 158.1\hat{k})$ kN.m

$-25\hat{j}$

$\vec{M}_{RA} = (-158.1\hat{i} + 259.6\hat{j} - 433.4)$ kN.m

c) Perpendicular Distance from line of action of T_{DF} to point A.

$$\vec{M}_A = \vec{r}_{AD} \times \vec{T}_{DF} = (-158.1\hat{i} + 474.3\hat{j} - 158.1\hat{k})\ kN.m$$

$$M_A = T_{DF}\, d = 50d \qquad d = \frac{M_A}{50}$$

$$M_A = N\sqrt{(-158.1)^2 + (474.3)^2 + (-158.1)^2} = 524.4\ kN.m$$

$$d = \frac{524.4}{50} = \boxed{10.49\ m}$$

d) Angle between T_{CB} & T_{CE}

$$\cos\theta = \vec{\lambda}_{CB} \cdot \vec{\lambda}_{CE}$$

$$\left(\frac{-10\hat{j} + 30\hat{k}}{\sqrt{1000}}\right) \cdot \left(\frac{10\hat{i} - 10\hat{j}}{\sqrt{200}}\right)$$

$$\cos\theta = \frac{\pm 100}{\sqrt{1000}\sqrt{200}} = 0.22361$$

$$\Rightarrow \theta = \boxed{77.08^\circ}$$

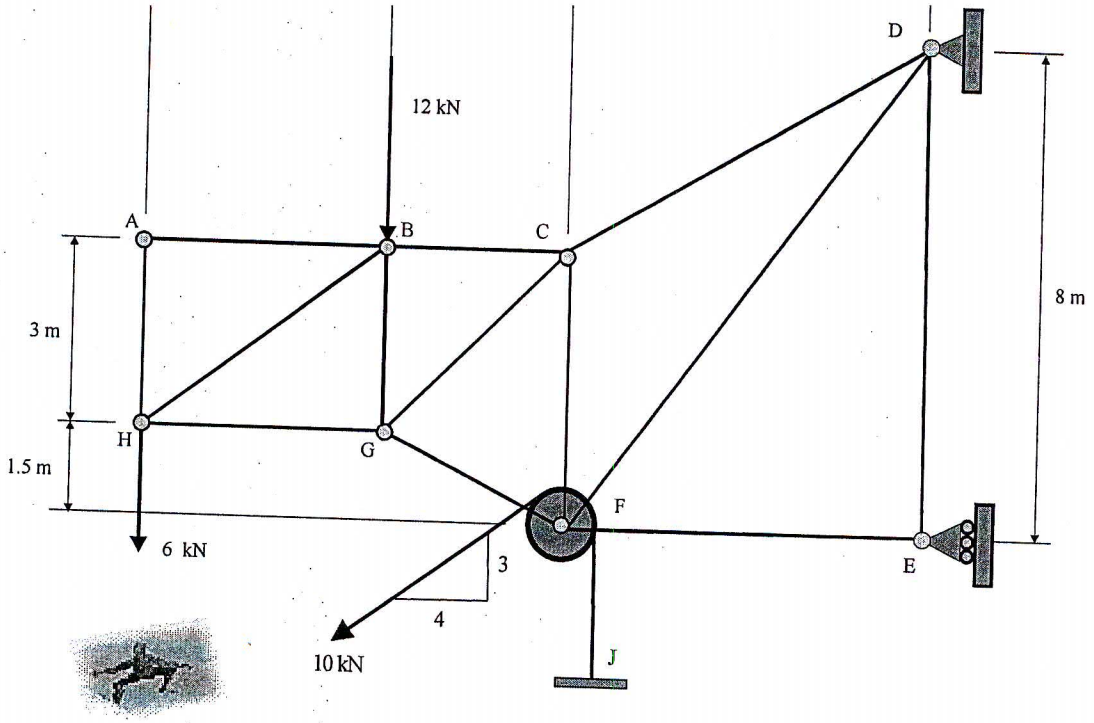


Figure 2

6 8 16 E_x

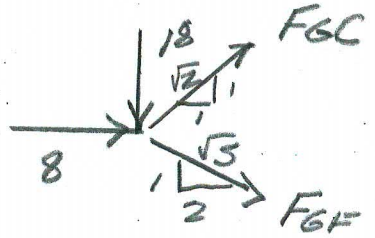
$E_x = +27.25\,kN$

$\therefore \vec{E}_x = 27.25\,kN \leftarrow$

$\Sigma F_x = 0 \quad -8 - 27.25 + D_x = 0 \quad D_x = +35.25\,kN \quad \therefore \vec{D}_x = 35.25\,kN \rightarrow$

$\Sigma F_y = 0 \quad -6 - 12 - 16 + D_y = 0 \quad D_y = +34\,kN \quad \therefore \vec{D}_y = 34\,kN \uparrow$

Pin AT G:



$\Sigma F_x = 0 \quad 8 + \frac{1}{\sqrt{2}} F_{GC} + \frac{2}{\sqrt{5}} F_{GF} = 0$

$\Sigma F_y = 0 \quad -18 + \frac{1}{\sqrt{2}} F_{GC} - \frac{1}{\sqrt{5}} F_{GF} = 0$

$\frac{3}{\sqrt{5}} F_{GF} = -26 \quad F_{GF} = -\frac{26\sqrt{5}}{3} = -19.38\,kN$

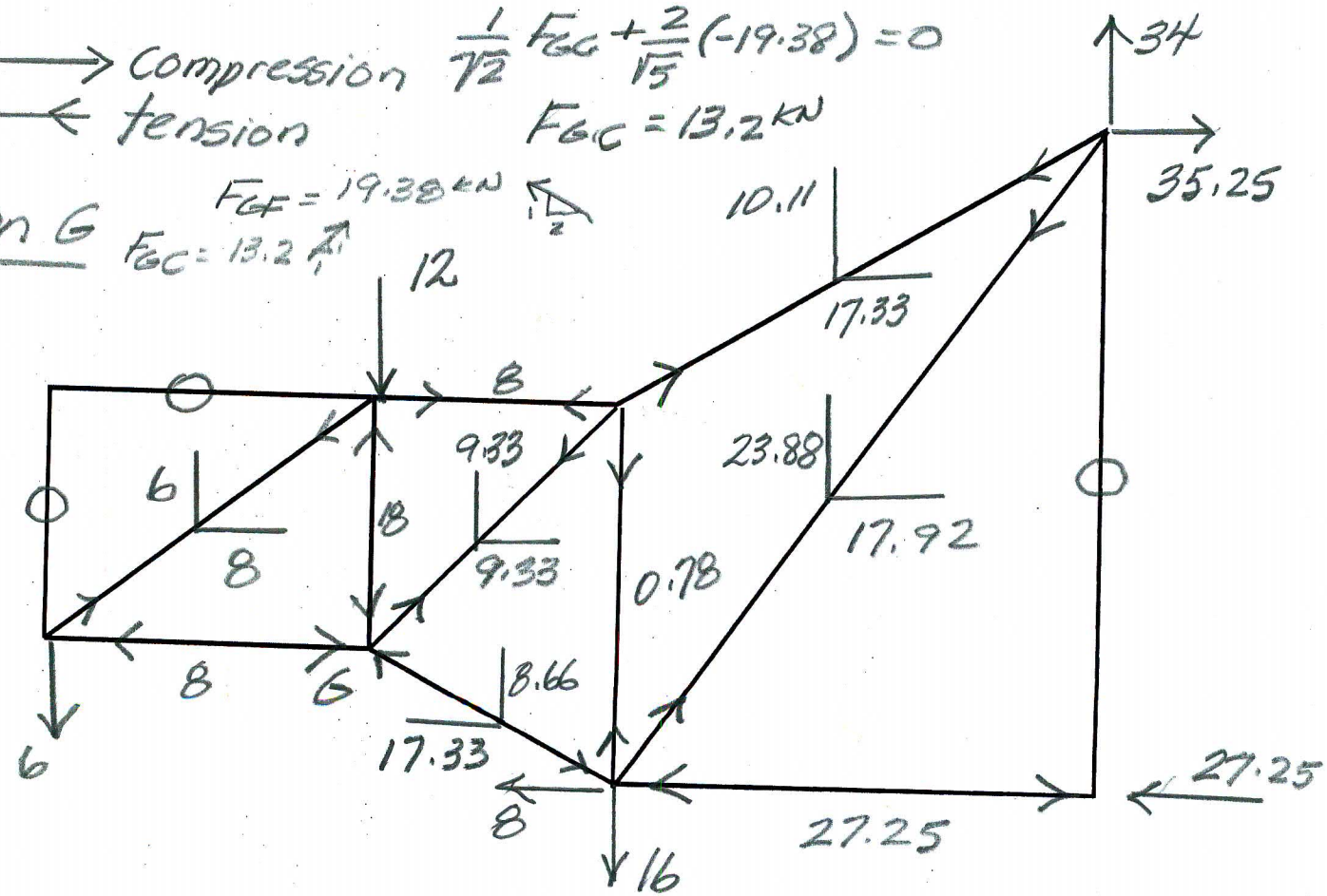
$\frac{1}{\sqrt{2}} F_{GC} + \frac{2}{\sqrt{5}}(-19.38) = 0$

$F_{GC} = 13.2\,kN$

⟷ Compression

⟶⟵ tension

On G $F_{GF} = 19.38\,kN$ $F_{GC} = 13.2$



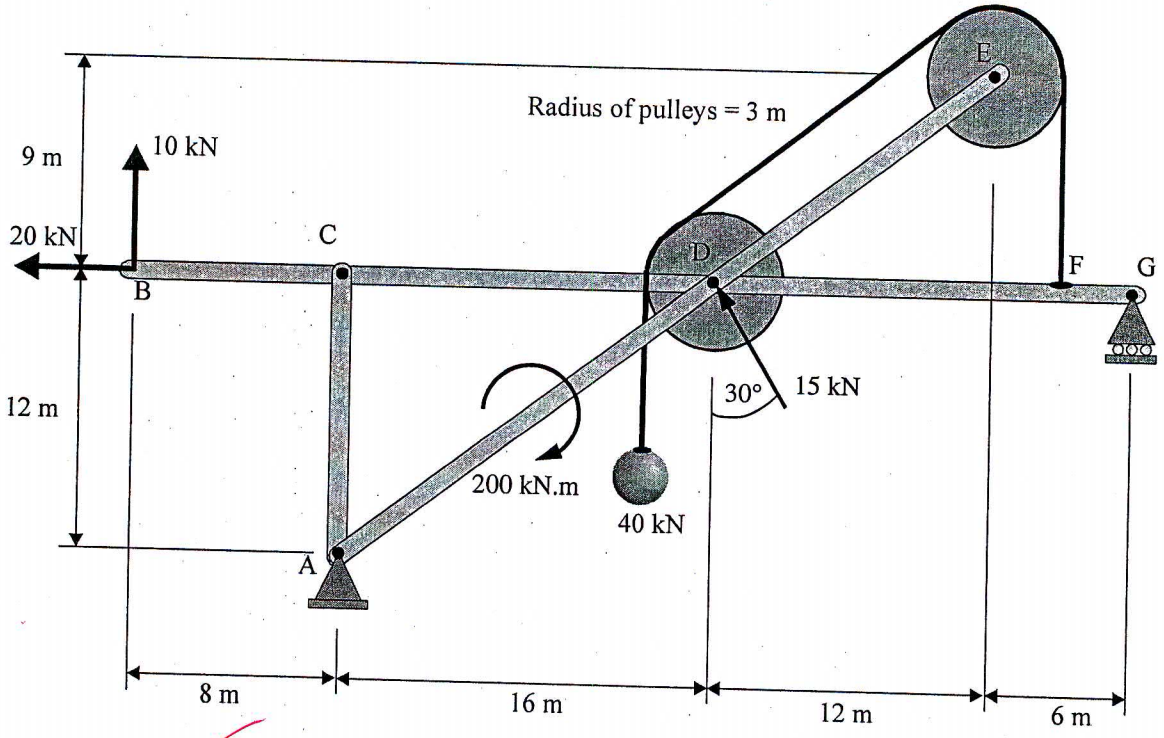
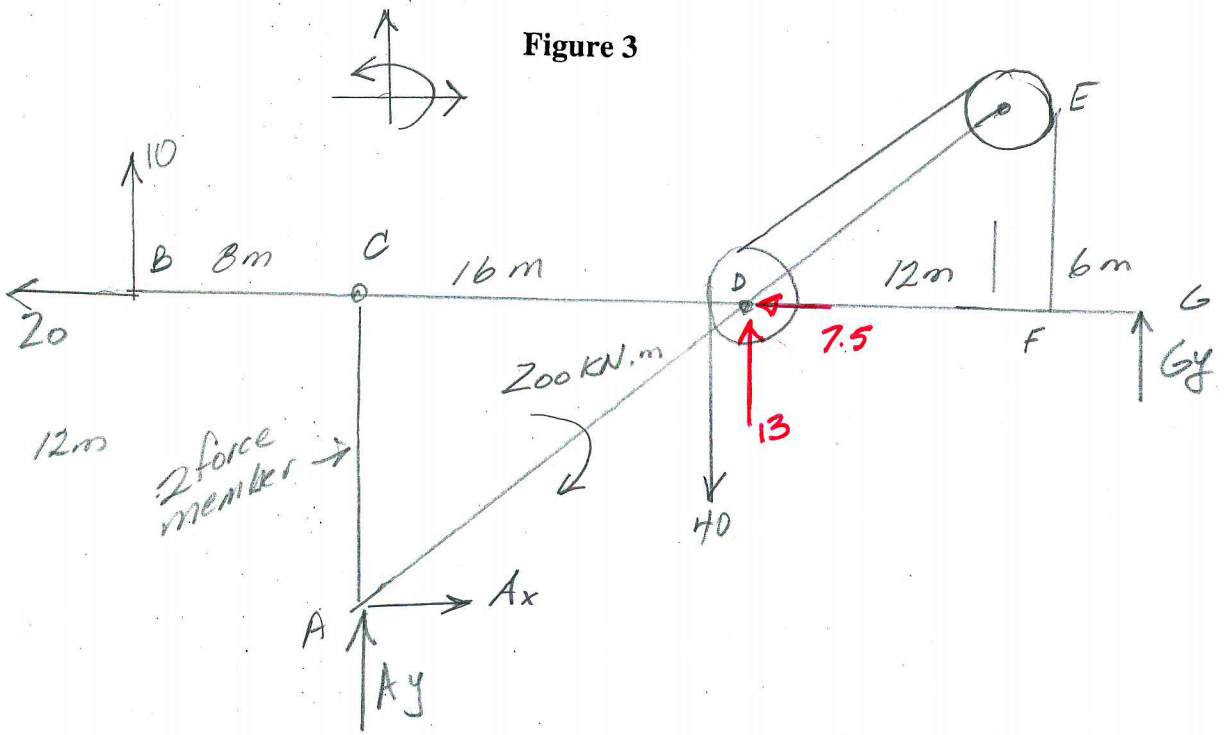
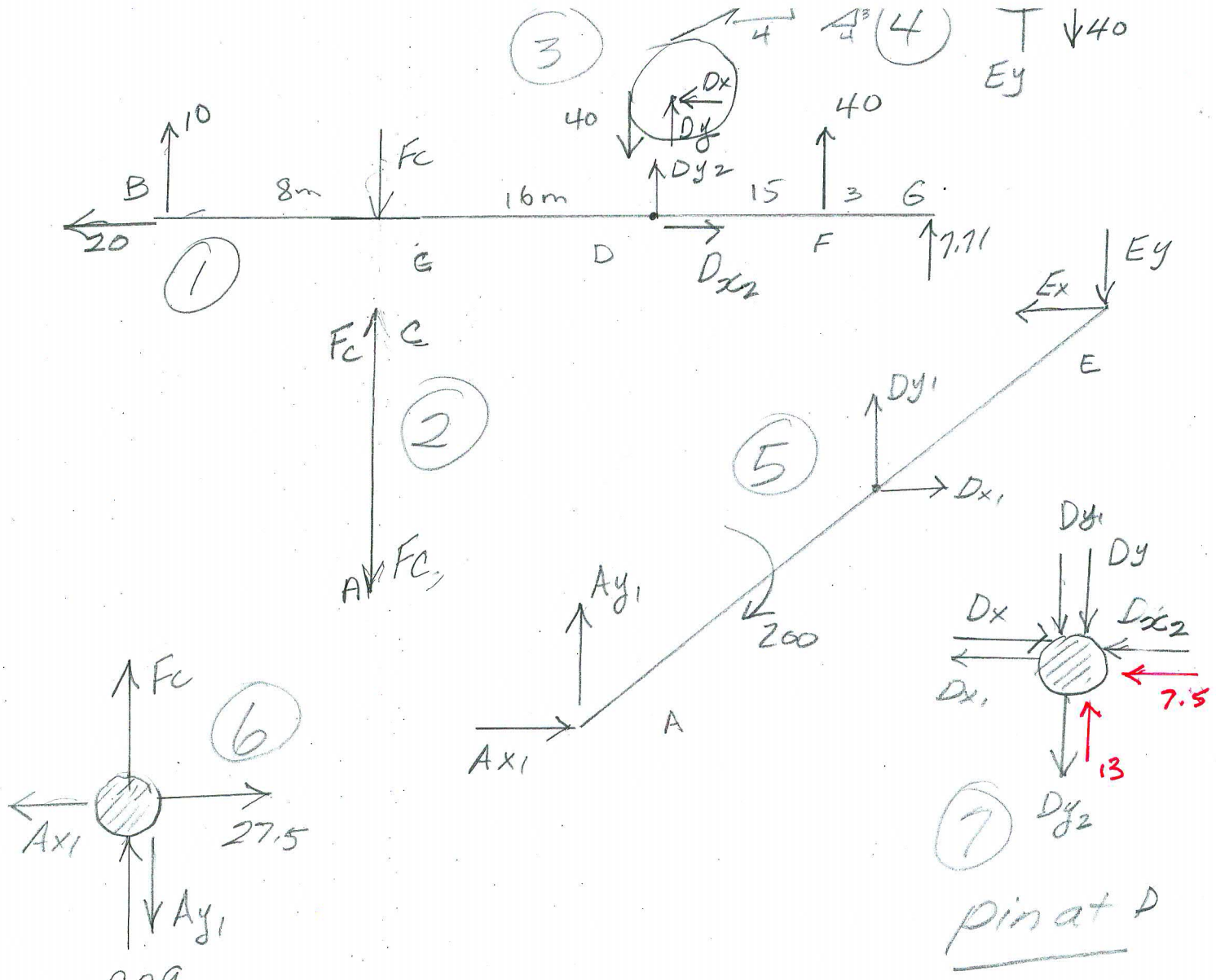

Radius of pulleys = 3 m
9 m
10 kN
20 kN
C
B
D
E
F
G
12 m
30°
15 kN
200 kN.m
40 kN
A
8 m
16 m
12 m
6 m

Figure 3


10
B
8m
C
16m
D
12m
6m
E
20
7.5
F
G
Gy
200 kN.m
13
12m
2 force member
40
A
Ax
Ay



pin at A

From (4) $\Sigma F_x = 0$ $E_x - \frac{4}{5}(40) = 0$

$E_x = +32$ kN $\vec{E}_x = 32$ kN $\rightarrow$ on the pulley

$\Sigma F_y = 0$ $-\frac{3}{5}(40) + E_y - 40 = 0$

$E_y = +64$ $\vec{E}_y = 64$ kN $\uparrow$ on the pulley

pin at D

From (3) $\Sigma F_x = 0$ $-D_x + \frac{4}{5}(40) = 0$

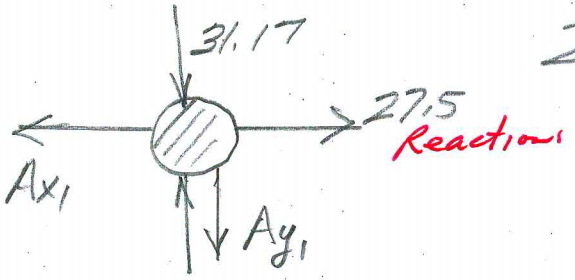
$D_x = +32$ kN $\vec{D}_x = 32$ kN $\leftarrow$ on the pulley

$\Sigma F_y = 0$ $-40 + D_y + \frac{3}{5}(40) = 0$

$D_y = +16$ kN

$\vec{D}_y = 16$ kN $\uparrow$ on the pulley

From (6) Re-draw



$\Sigma F_x = 0 \quad 27.5 - A_{x_1} = 0$

$A_{x_1} = +27.5$

$\therefore \vec{A}_{x_1} = 27.5 \overset{kN}{\leftarrow}$ on the pin at A

$\Sigma F_y = 0$

$-31.17 + 9.29 - A_{y_1} = 0$

$A_{y_1} = -21.88^{kN}$

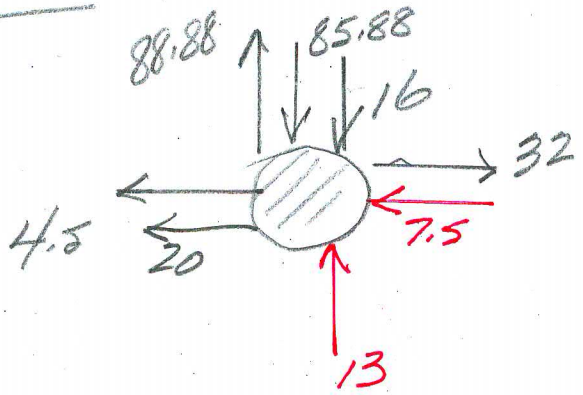
$\therefore A_{y_1} = 21.88^{kN} \uparrow$ on the pin at A.

$\Sigma F_y = 0 \quad -21.88 + D_{y_1} - 64 = 0$

$D_{y_1} = +85.88\ kN$

$\vec{D}_{y_1} = 85.88 kN \uparrow$ on ADE

From 7 Re-draw

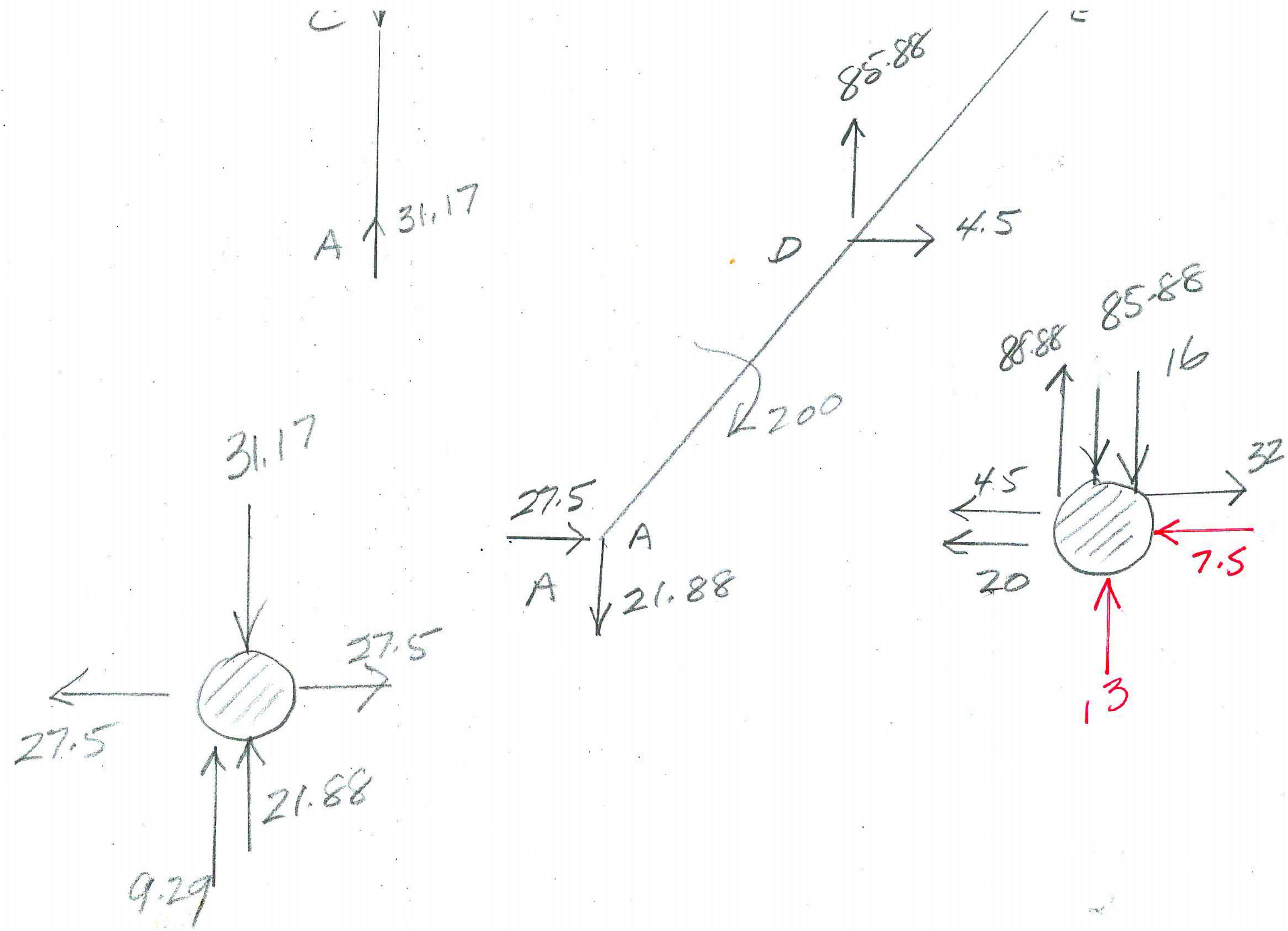


$\Sigma F_x = -4.5 - 20 - 7.5 + 32 = 0$

$0 = 0$ ✓

$\Sigma F_y = 88.88 - 85.88 - 16 + 13 = 0$

$0 = 0$ ✓


C
A
31.17
85.88
D
4.5
88.88
85.88
16
200
31.17
27.5
A
A
21.88
4.5
32
20
7.5
27.5
27.5
13
21.88
9.29