TERM TEST #2

NOV 9, 2011

SOLUTIONS.

QUESTION 1

Distributed loads are applied to the shape shown in Figure 1(a). In addition to these distributed loads, a *10 kN* force and a *30 kN.m* clockwise couple moment are applied.

Replace the system of forces and couple acting on the shape with a single force and state where this force intersects the *x* and *y* axis.
(Indicate your results on Figure 1(b) provided on the next page.)

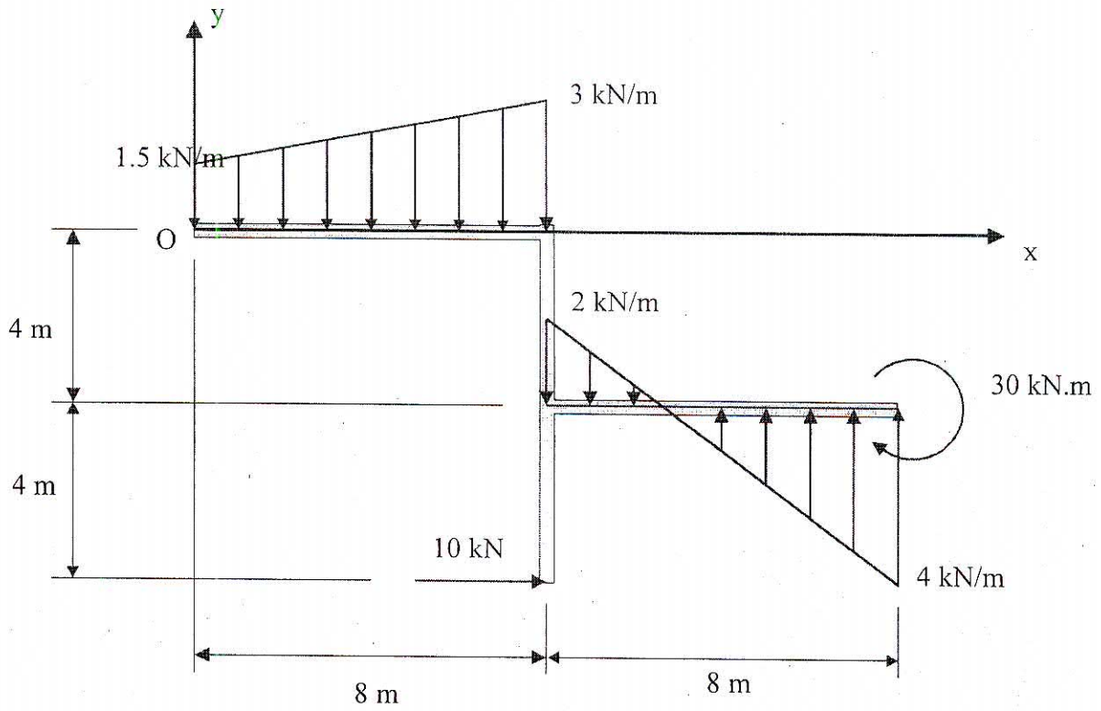
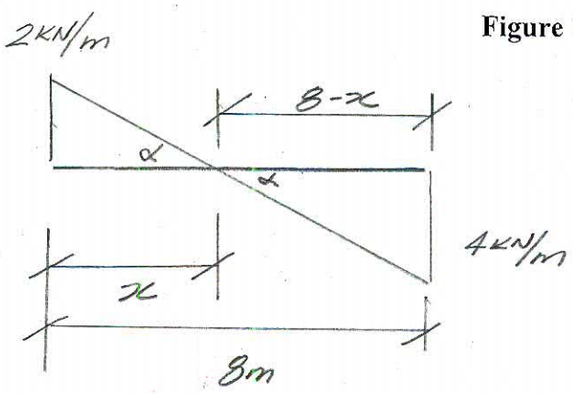


Figure 1 (a)



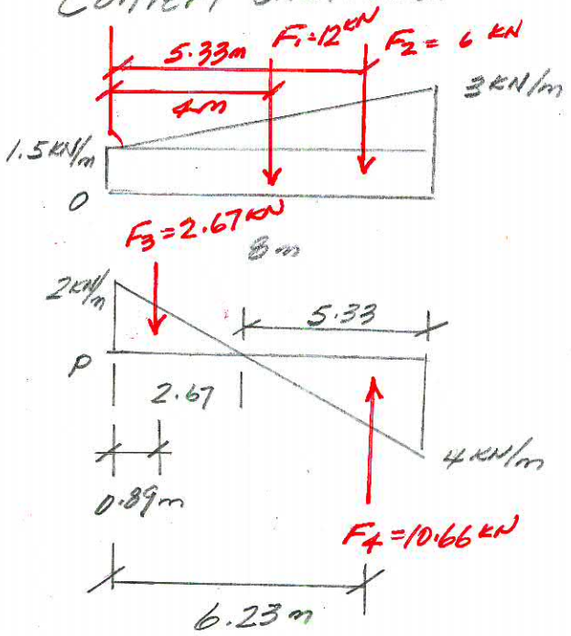
$\tan\alpha = \frac{2}{x} = \frac{4}{8-x}$

$2(8-x) = 4x$

$16 = 6x \quad x = 2.67\,m$

$8-x = 5.33\,m$

Convert distributed loads to concentrated forces:

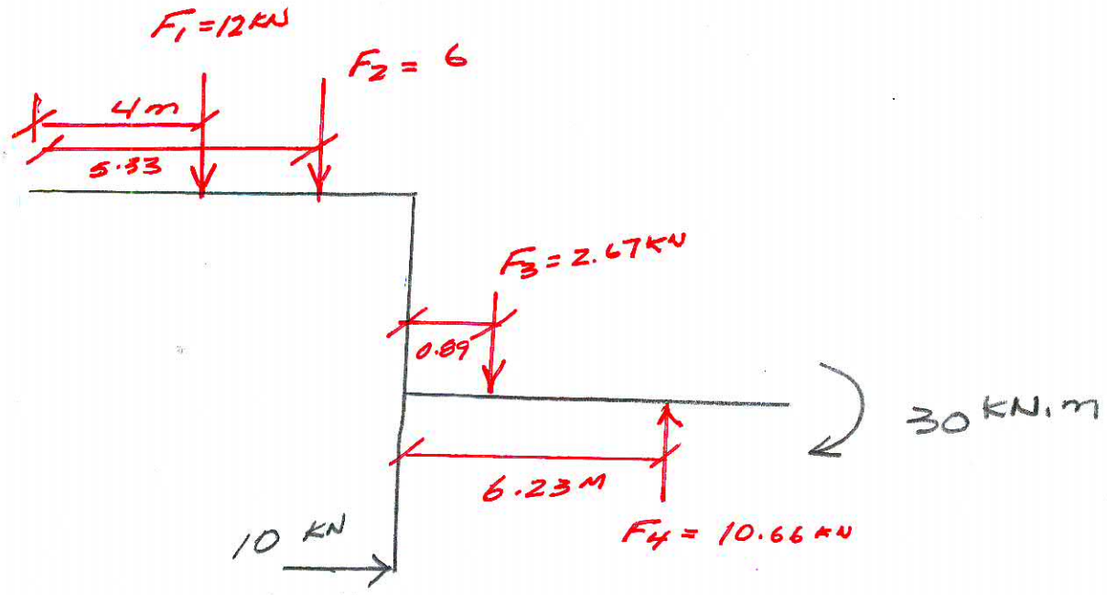


$F_1 = 1.5(8) = 12\,KN$ @ $4\,m$

$F_2 = \frac{(3-1.5)8}{2} = 6\,KN$ @ $\frac{2}{3}(8) = 5.33\,m$

$F_3 = \frac{2(2.67)}{2} = 2.67\,KN$ @ $\frac{2.67}{3} = 0.89\,m$ from P

$F_4 = \frac{4(5.33)}{2} = 10.66\,KN$ @ $2.67 + \frac{2}{3}(5.33) = 6.23\,m$ from P



$$R_x = \Sigma F_x = +10\,KN$$

$$\therefore \vec{R}_x = 10\,KN \rightarrow$$

$$R_y = \Sigma F_y = -12-6-2.67+10.66$$

$$= -10\,KN$$

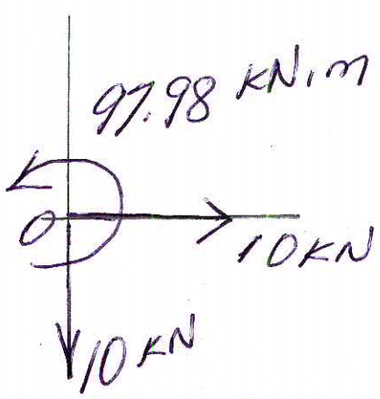
$$\therefore \vec{R}_y = 10\,KN \downarrow$$

$$M_{R_O} = \Sigma M_O = -12(4)-6(5.33)$$

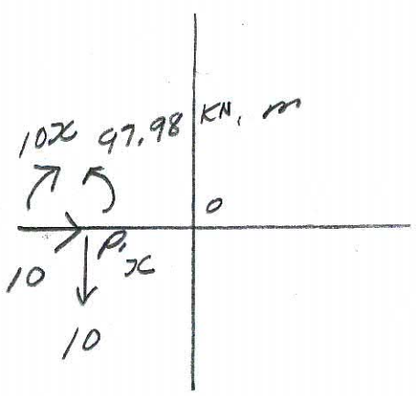
$$-2.67(8+0.89)+10.66(8+6.23)$$

$$-30+10(8)$$

$$M_{R_O} = +97.98\,kN.m \quad \vec{M}_{R_O} = 97.98\,KN.m \circlearrowleft$$



Equivalent Force Couple at O

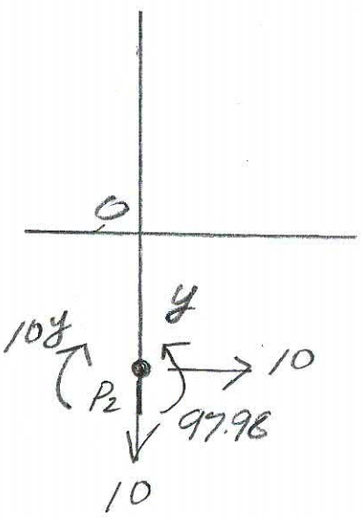


$$M_{P_1} = 0$$

$$-10x+97.98=0$$

$$x = 9.8\,m$$

Left of O



$$M_{P_2} = 0$$

$$-10y+97.98=0$$

$$y = 9.8\,m$$

below O

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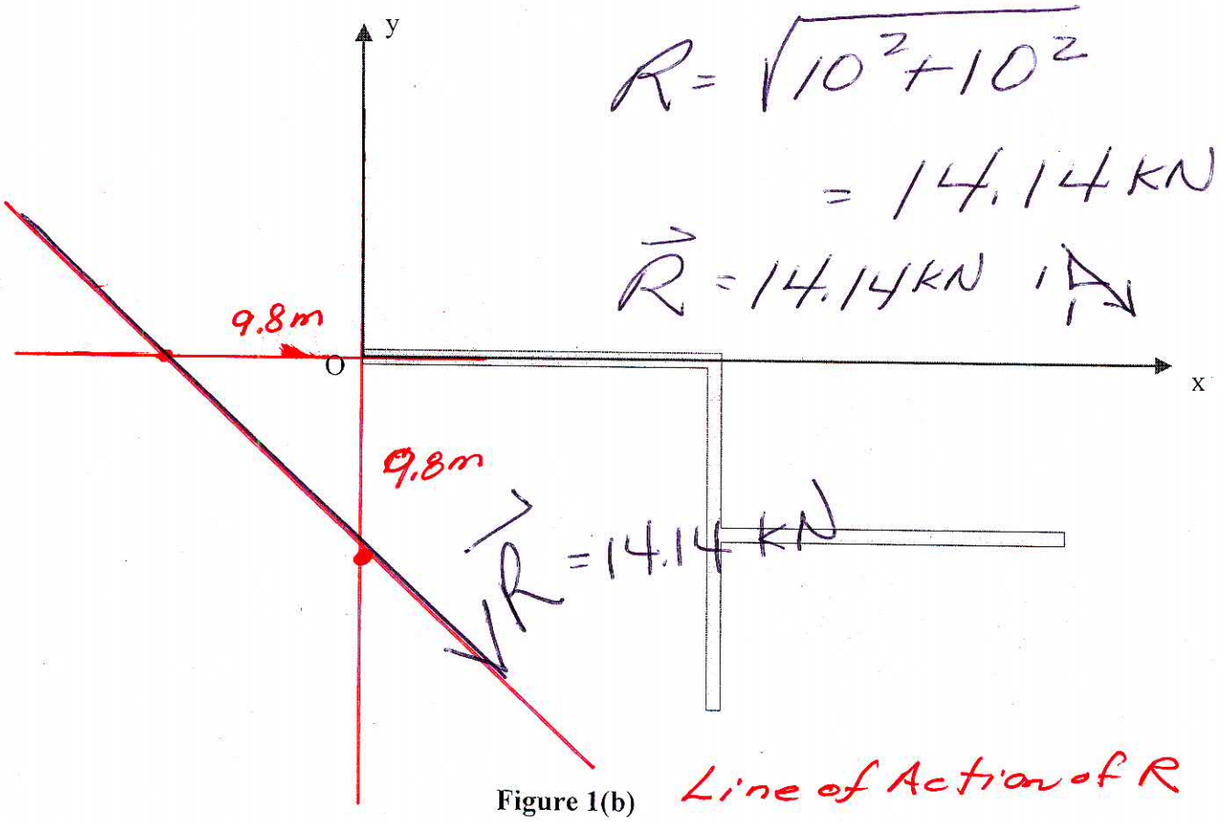


$R = \sqrt{10^2 + 10^2}$

$= 14.14\ kN$

$\vec{R} = 14.14\ kN \swarrow$

Figure 1(b) Line of Action of R

QUESTION 2

Three members of a frame supported by a rigid (fixed) external support at *D* are connected by a common pin at *B*. A 1 m radius smooth pulley is attached to member *BE* of the frame. A cable passes over this pulley and is attached to the frame at *C* and *F*.

Forces of *20 kN* and *50 kN* are applied at points *A* and *G* respectively. A *30 kN.m* clockwise couple moment is applied at the end of member *BFG*.

Determine:

a) The external reactions at support *D*,

b) The forces acting on each member of the frame including the pulley. **Indicate your final results on separate Free Body Diagrams of each member of the frame.**

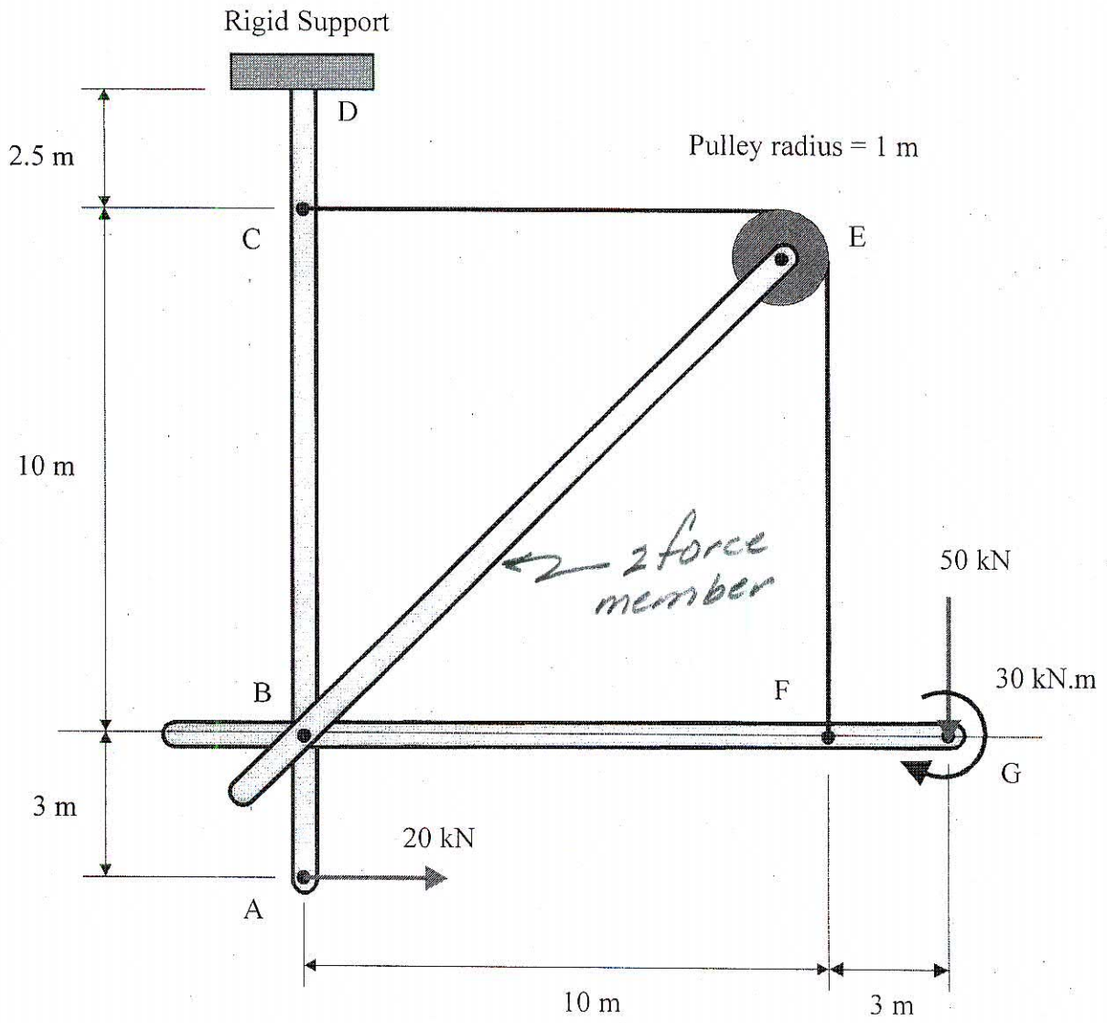
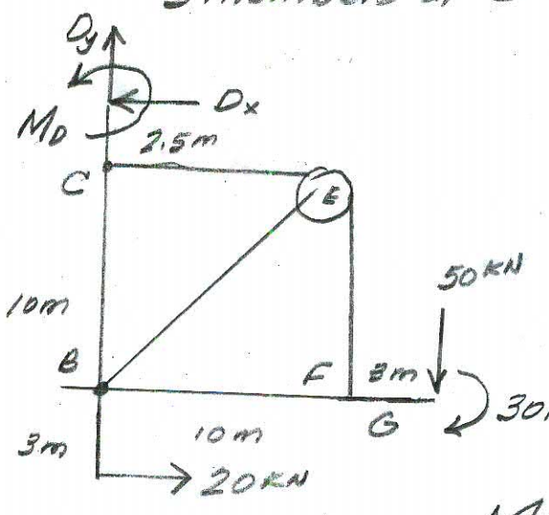


Figure 2

Note: BE is a 2 force member

3 members of B connected by a common pin



$\Sigma F_x = 0 \quad -D_x + 20 = 0$

$D_x = +20\,kN$

$\therefore \vec{D}_x = 20\,kN \leftarrow$

$\Sigma F_y = 0 \quad D_y - 50 = 0$

$D_y = +50\,kN$

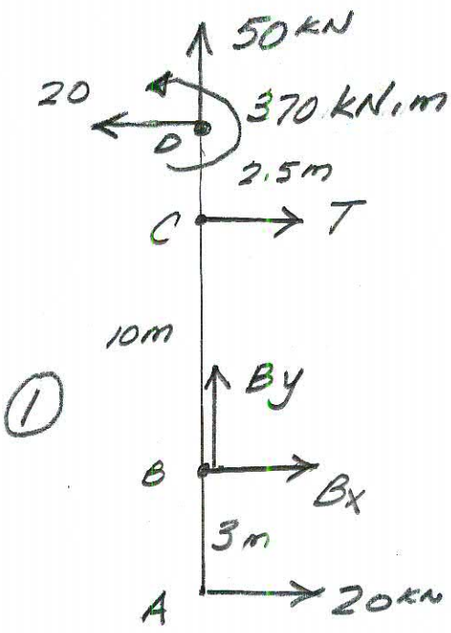
$\therefore \vec{D}_y = 50\,kN \uparrow$

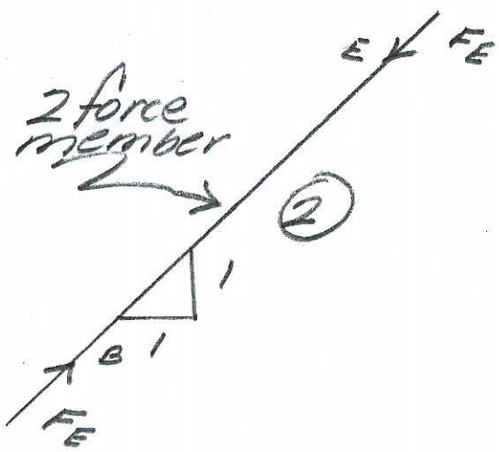
$\Sigma M_D = 0$

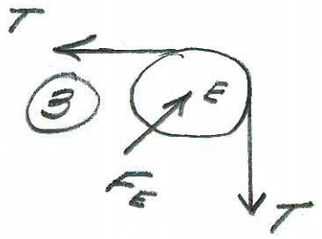
$M_D + 20(15.5) - 50(13) - 30 = 0$

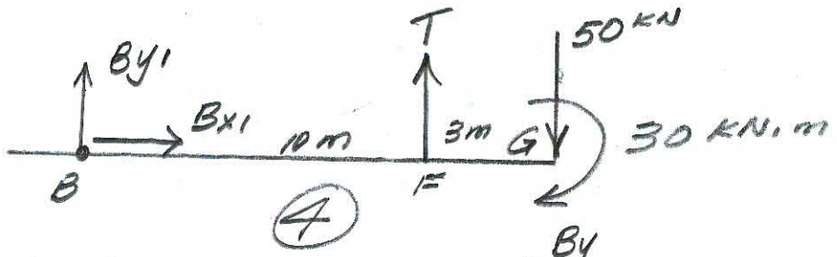
$M_D = +370\,N.m \quad \therefore \vec{M}_D = 370\,N.m \circlearrowleft$

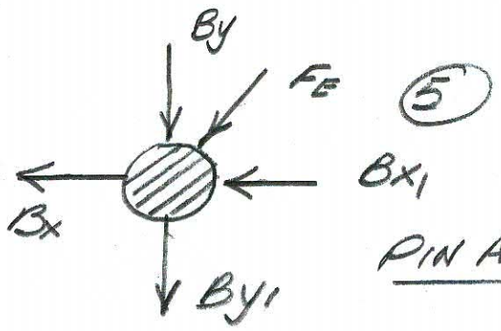
Substructure:











PIN AT B

From (4) $\sum M_B = 0$ $\quad T(10) - 50(13) - 30 = 0$

$$T = 68 \text{ kN}$$

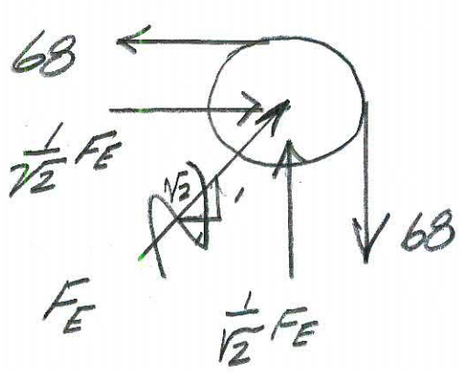
$\sum F_x = 0 \quad B_{x1} = 0$

$\sum F_y = 0 \quad B_{y1} + 68 - 50 = 0$

$$B_{y1} = -18 \text{ kN}$$

$$\therefore \vec{B}_{y1} = 18 \text{ kN} \downarrow \text{ on member BFG}$$

FROM (3) Redraw (3)



$\sum F_x = 0$

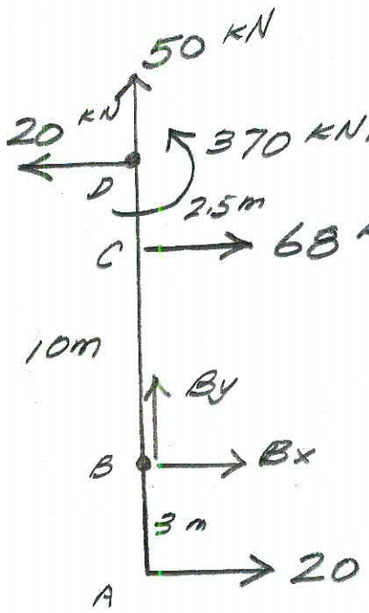
$$-68 + \frac{1}{\sqrt{2}} F_E = 0$$

$$F_E = +96.17 \text{ kN}$$

$$\therefore \vec{F}_E = 96.17 \text{ kN} \nearrow$$

on the pulley

Redraw ①



$\Sigma F_x = 0$

$-20 + 68 + B_x + 20 = 0$

$B_x = -68$ kN

$\therefore B_x = 68$ kN ← on member ABCD

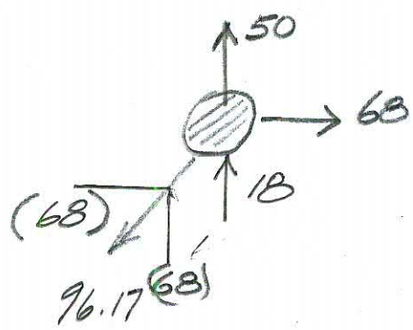
$\Sigma F_y = 0$

$50 + B_y = 0$

$B_y = -50$ kN

$\therefore \vec{B}_y = 50$ kN ↓ on member ABCD

Redraw ⑤ Pin at B



$\Sigma F_x = 0$

$68 - 68 = 0$

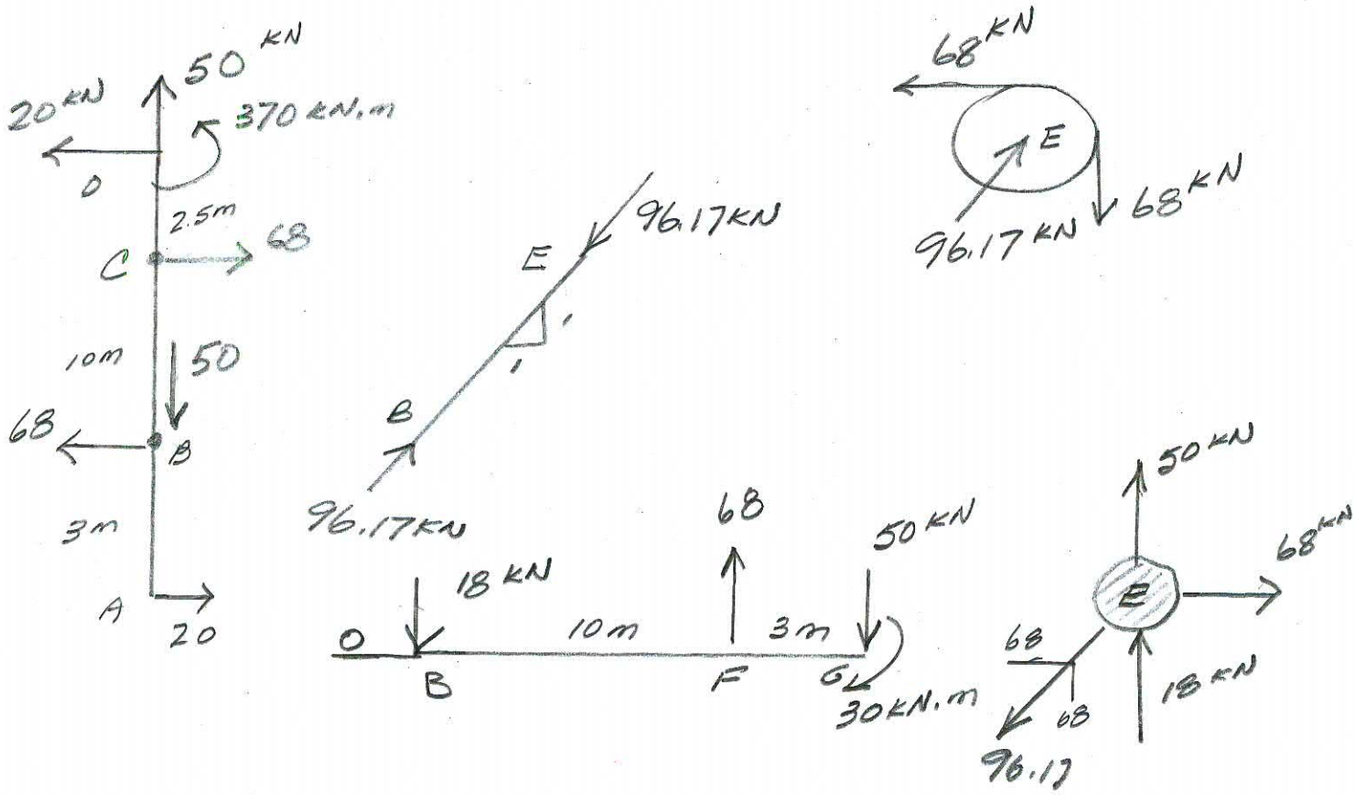
$0 = 0$ ✓ checks

$\Sigma F_y = 0$

$50 + 18 - 68 = 0$

$0 = 0$ ✓ checks

FINAL RESULTS



QUESTION 3

A simple truss has a hinge (pin) support at *D*. Member *AB* is a "short link". Two smooth pulleys each of radius *0.5 m* are attached to the truss at joints *F* and *I* respectively. A cable passes over the pulleys and is attached to an external support at *E*. A *50 kN* weight is suspended from the other end of the cable.

Determine:
The force in each member of the truss and state whether the member is in tension, compression or a zero force member.

PLACE YOUR RESULTS ON THE FIGURE PROVIDED.

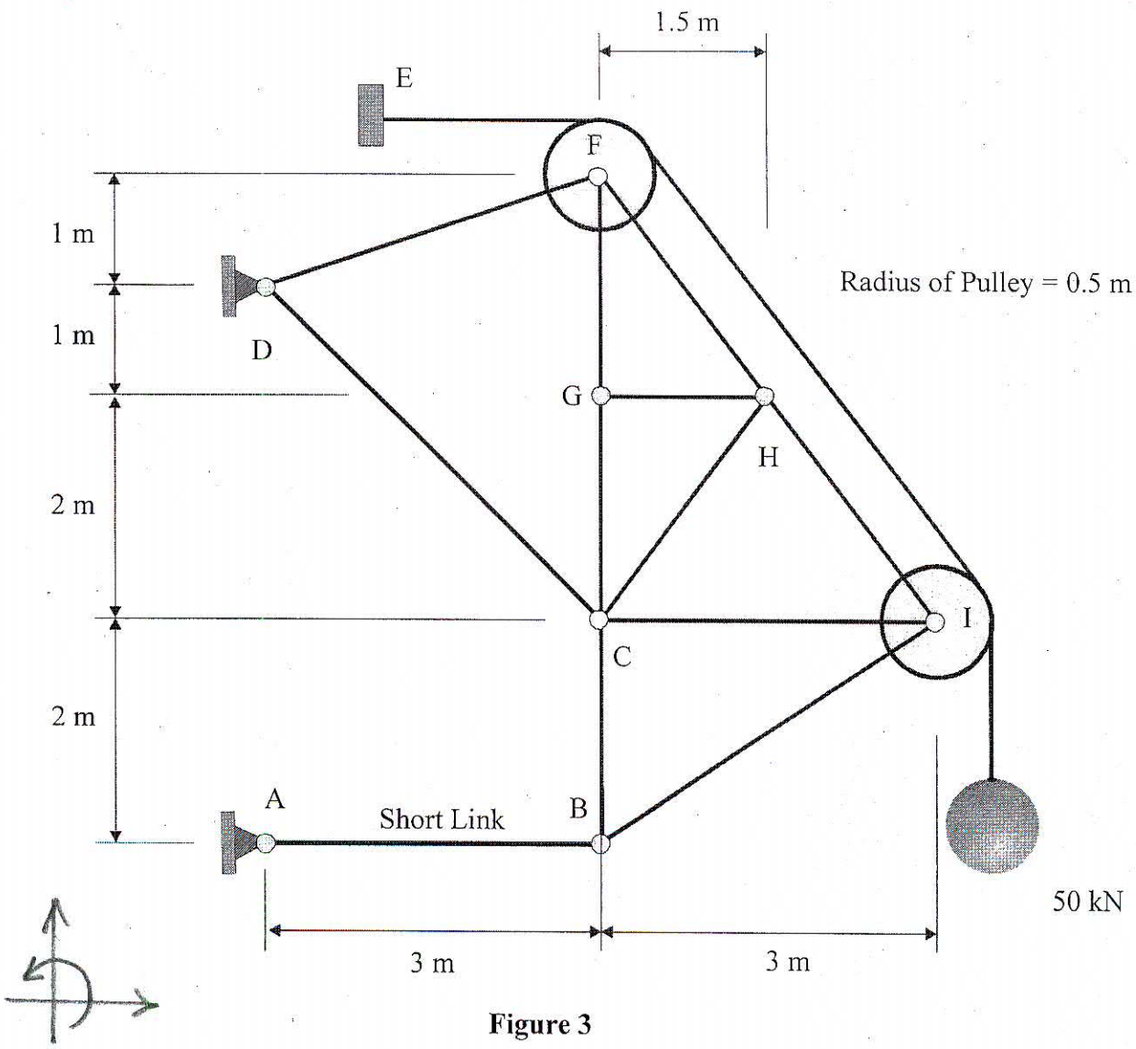
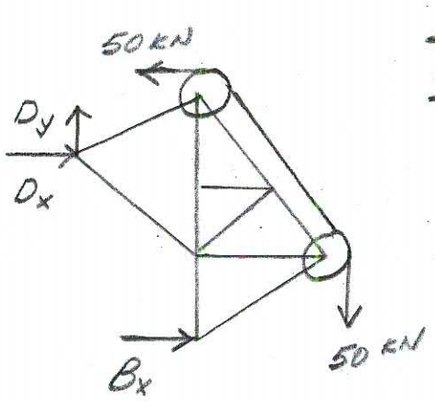


Figure 3

FBD of Entire Truss (Pulleys left attached):



$\Sigma F_x = 0 \quad D_x + B_x - 50 = 0 \quad (1)$

$\Sigma F_y = 0 \quad D_y - 50 = 0 \quad (2)$

$D_y = +50\ kN \therefore \vec{D}_y = 50\ kN \uparrow$

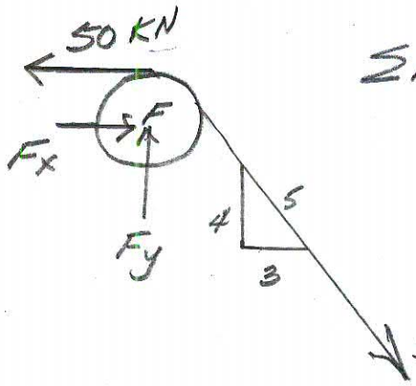
$\Sigma M_D = 0 \quad 50(1.5) - 50(6.5) + B_x(5) = 0 \quad (3)$

$B_x = +50\ kN \therefore \vec{B}_x = 50\ kN \rightarrow$

From (1) $D_x + 50 - 50 = 0$

$\therefore \vec{D}_x = 0$

Truss Reactions on the Pulleys:



$\Sigma F_x = 0$

$F_x - 50 + \frac{3}{5}(50) = 0$

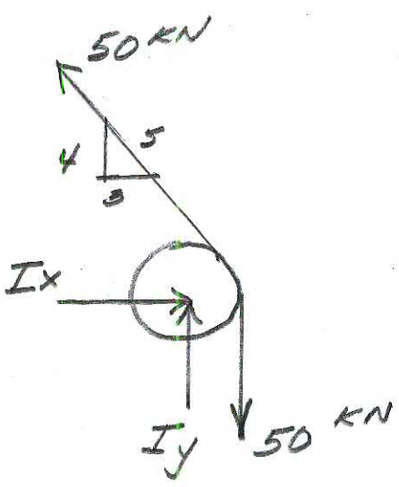
$F_x = +20\,kN$

$\vec{F}_x = 20\,kN \rightarrow$ on the pulley

$\Sigma F_y = 0$

$F_y - \frac{4}{5}(50) = 0 \quad F_y = +40\,kN$

$\therefore \vec{F}_y = 40\,kN \uparrow$ on the pulley



$\Sigma F_x = 0$

$-\frac{3}{5}(50) + I_x = 0$

$I_x = +30\,kN$

$\therefore \vec{I}_x = 30\,kN \rightarrow$ on the pulley

$\Sigma F_y = 0$

$\frac{4}{5}(50) + I_y - 50 = 0$

$I_y = +10\,kN$

$\therefore \vec{I}_y = 10\,kN \uparrow$ on the pulley

These reactions are applied opposite on the truss (Newton's 3RD LAW).

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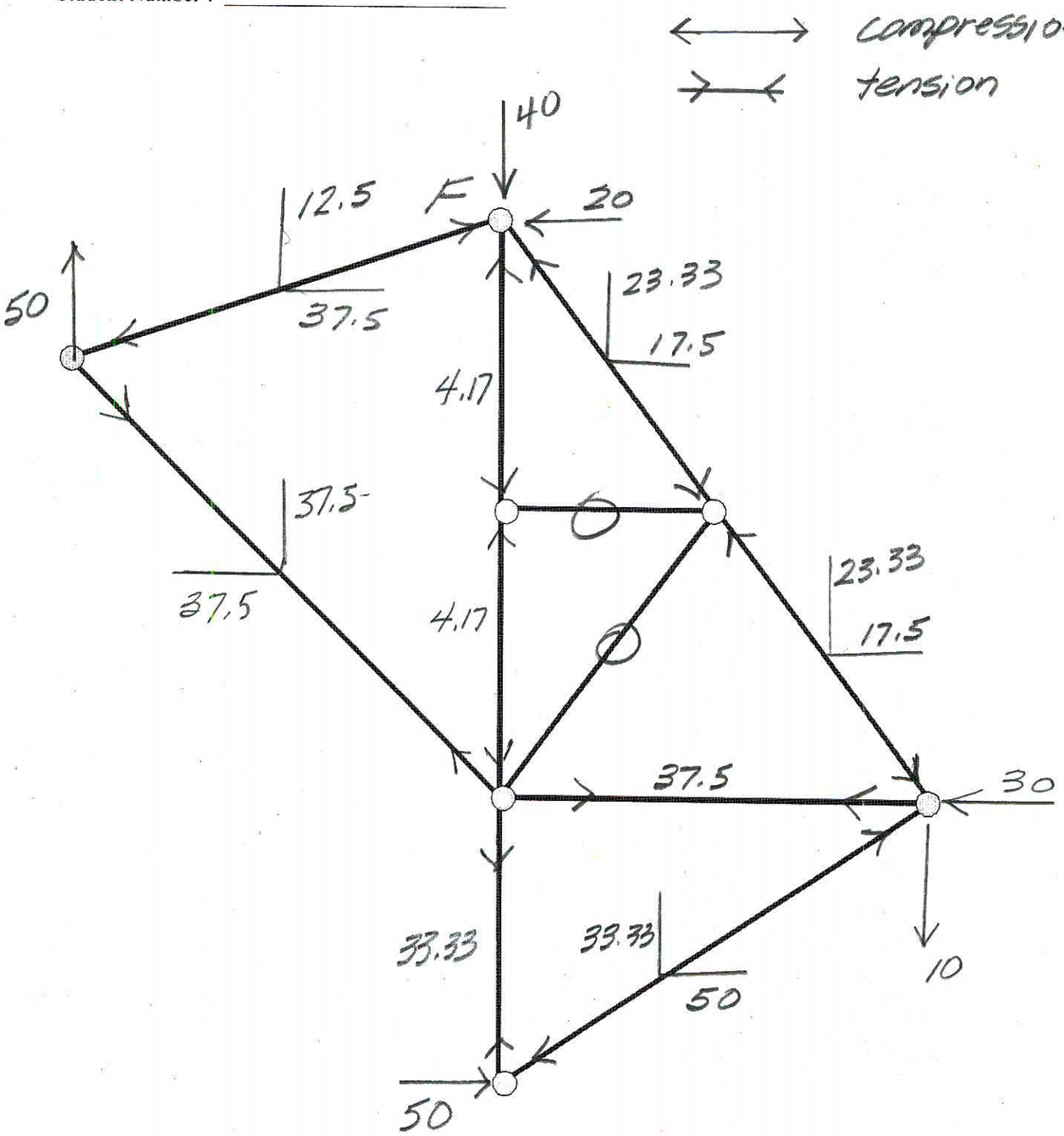

Check F

$\frac{50}{3} = \frac{y}{2}$ $y = 33.33$

$\Sigma F_x = 37.5 - 20 - 17.5 = 0$

$0 = 0$ ✓

$\frac{23.33}{4} = \frac{x}{3}$ $x = 17.5$

$\Sigma F_y = 12.5 + 4.17 + 23.33 - 40 = 0$

$\frac{37.5}{3} = \frac{y}{1}$ $y = 12.5$

$0 = 0$ ✓