Statics CE 201
Sections 3&4 (091)
Solution of H.W# 10

Pr.# 1.

- Given :- the figure shown Fig. P1

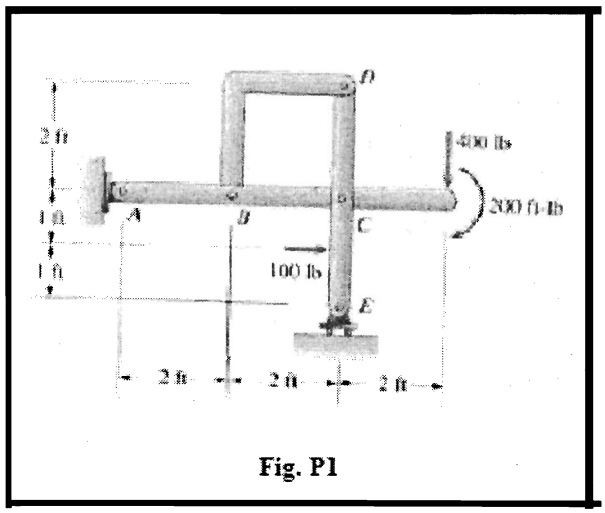


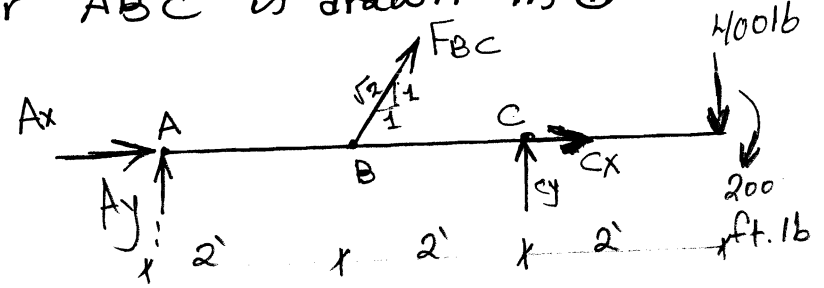
Fig. P1

- Required :-

Forces on member ABC.

- Solution :-

The FBD of member ABC is drawn in ① as shown.



FBD ①

Note that BD is a two-force member. Also, Note that there are 5 unknowns & 3 equations. thus, we can not start with member ABC. ⇒

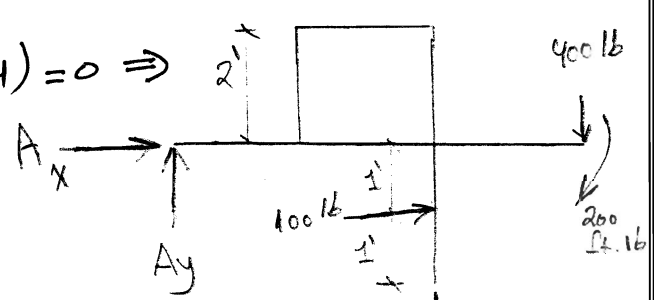
Take the whole frame (FBD ②):

$\pm\rightarrow \sum F_x = 0 \Rightarrow A_x + 100 = 0 \Rightarrow$ **$A_x = -100\ lb = 100\ lb \leftarrow$**

$+\circlearrowleft \sum M_E = 0$ (why E ?!)

$100(2) - 100(1) - 200 - 400(2) - A_y(4) = 0 \Rightarrow$

$A_y = -225\ lb = 225\ lb \downarrow$



FBD②

Now, come back to FBD ①,

→

$+\circlearrowleft \Sigma M_C = 0$ (why C ?!) $\Rightarrow$

$-200 - 400(2) \oplus 225(4) - F_{BC}\left(\frac{1}{\sqrt{2}}\right)(2) = 0$

$\Rightarrow$ $F_{BC} = -70.711$ lb $= 70.711$ lb $\swarrow$ "C"

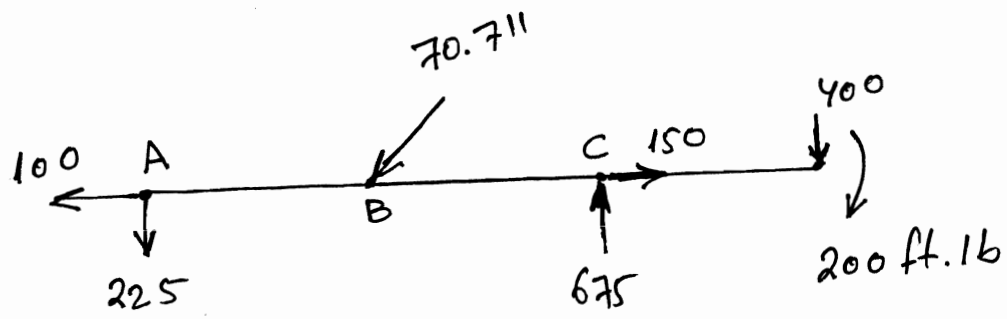
$\overset{+}{\rightarrow} \Sigma F_x = 0 \Rightarrow -100 - 70.711\left(\frac{1}{\sqrt{2}}\right) + C_x = 0 \Rightarrow$

$C_x = 150$ lb $\rightarrow$

$+\uparrow \Sigma F_y = 0 \Rightarrow -225 - 400 - 70.711\left(\frac{1}{\sqrt{2}}\right) + C_y = 0$

$\Rightarrow C_y = 675$ lb $\uparrow$

The forces on member ABC are shown in the figure below in the correct directions.



All in lb

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Problem 2 :-

-Given :

. The figure shown.

. w = 40 lb.

- Required :.

forces on members ABCD and CEG.

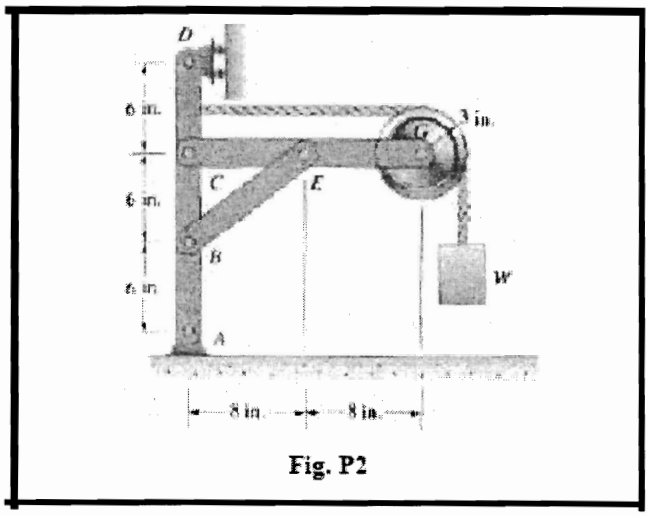
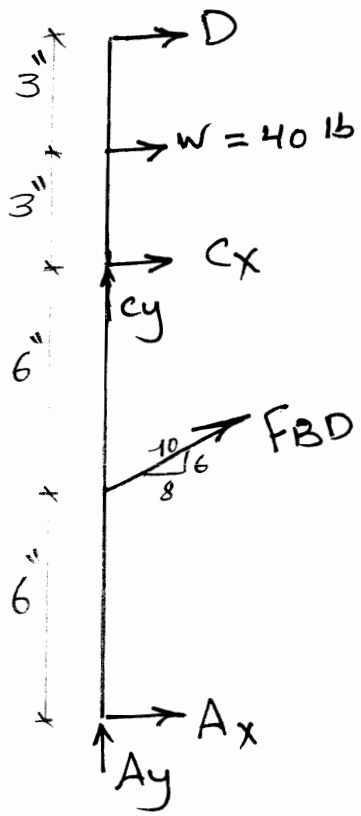


Fig. P2

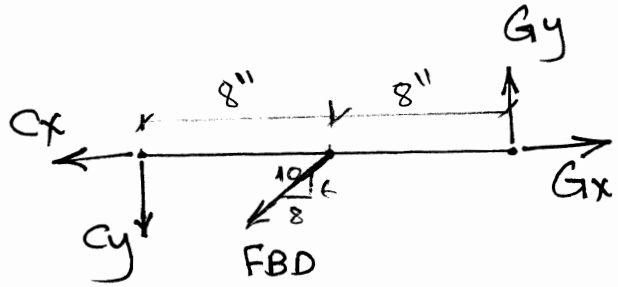
- Solution :-

The FBD's of members ABCD and CEG are drawn as shown in ① and ②.

Note that BE is a two-force member.



FBD ①



FBD ②

Note that in FBD ①, there are 6 unknowns, and in FBD ②, there are 5 unknowns. Thus, we can not start with either one.

→

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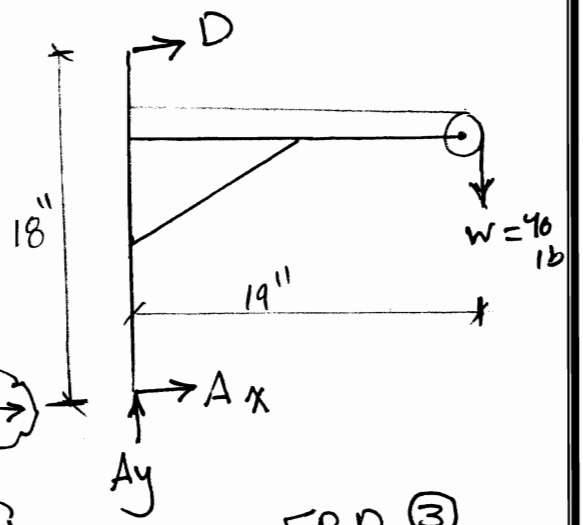
Let's first find the reactions from the FBD of the whole frame as shown in ③.

$\overset{+}{\circlearrowleft} \sum M_A = 0 \Rightarrow$

$-40(19) - D(18) = 0 \Rightarrow$

$D = -42.222 \text{ lb} = 42.222 \text{ lb} \leftarrow$



FBD ③

$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow$

$A_x - 42.222 = 0 \Rightarrow A_x = 42.222 \text{ lb} \rightarrow$

$+\uparrow \sum F_y = 0 \Rightarrow A_y - 40 = 0 \Rightarrow A_y = 40 \text{ lb} \uparrow$

Now, we come back to FBD ①,

$\overset{+}{\circlearrowleft} \sum M_C = 0 \Rightarrow 42.222(12) \underset{-(-)}{\overset{(+)}{}} 42.222(6) - 40(3) + F_{BD}\left(\frac{8}{10}\right)(6) = 0$

$\Rightarrow F_{BD} = -133.3 \text{ lb} = 133.3 \text{ lb} \swarrow$ "C"

$+\uparrow \sum F_y = 0 \Rightarrow 40 + \left[-133.33\left(\frac{6}{10}\right)\right] + C_y = 0 \Rightarrow$

$C_y = 40 \text{ lb} \uparrow$

$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow 42.222 + 40 - 42.222 - 133.33\left(\frac{8}{10}\right) + C_x = 0$

$\Rightarrow C_x = 66.67 \text{ lb} \rightarrow$

Now, we take FBD ②,

F_{EB}, C_x & C_y are equal and opposite (member CEG compared with member ABCD). $\Rightarrow$

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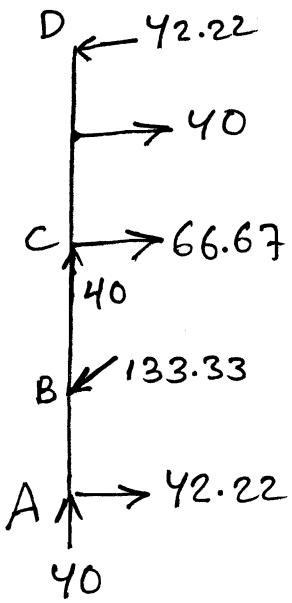
$\Rightarrow$ $C_x = 66.67$ lb $\leftarrow$, $C_y = 40$ lb $\downarrow$

$F_{EB} = 133.33$ lb $\nearrow$ "C"

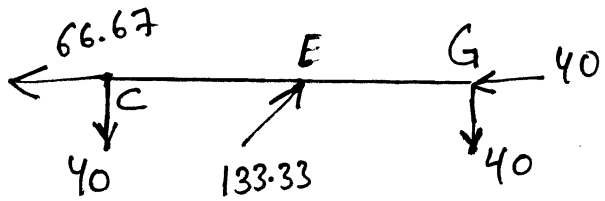
$\overset{+}{\rightarrow} \Sigma F_x = 0 \Rightarrow -66.667 + 133.33\left(\frac{8}{10}\right) + G_x = 0 \Rightarrow G_x = -40$ lb $= 40$ lb $\leftarrow$

$+\uparrow \Sigma F_y = 0 \Rightarrow -40 + 133.33\left(\frac{6}{10}\right) + G_y = 0 \Rightarrow G_y = -40$ lb $= 40$ lb $\downarrow$

The results can be presented on the members as shown below. All units in lb.



member ABCD



member CEG

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Problem 3 :-

- Given:
  - The figure shown.
  - Pin support B force = 24 kN (max.)
- Required:
  - The largest weight W.

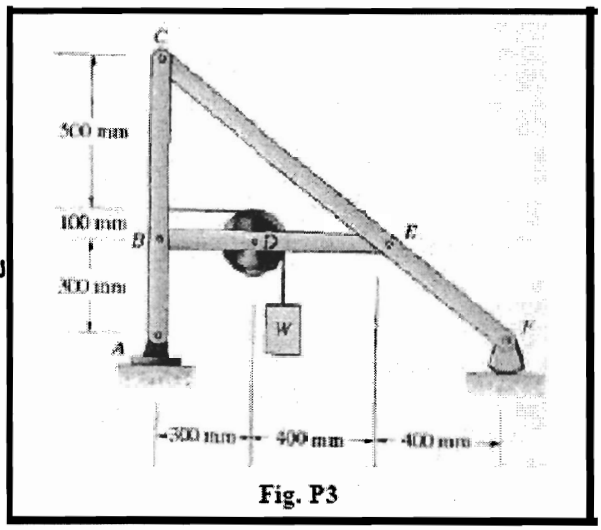


Fig. P3

- solution :-

In order to solve this problem, we need to find the force resultant at pin B, expressed in terms of W (i.e function of W: $B = f(W)$). Then we set B(W) equal to 24 kN. "B" is "common" in member ABC and member BDE. However, we need to start by taking the entire frame (FBD ①). Note that, no internal forces appear! only W and the reactions at A and F. (why?!)

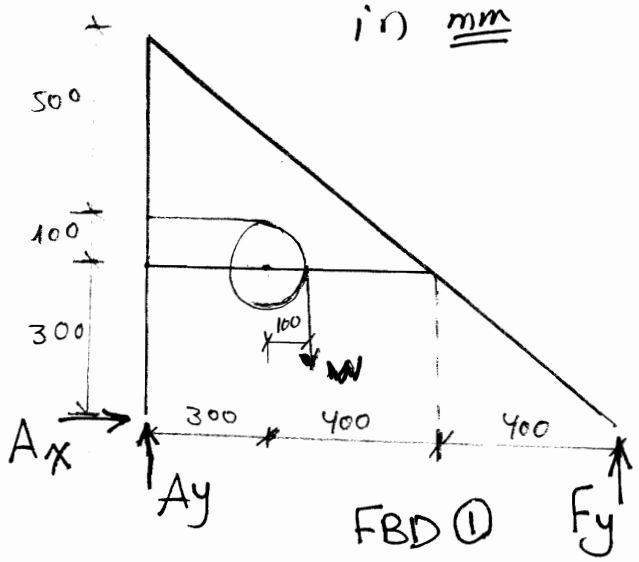
$+\uparrow \Sigma F_x = 0 \Rightarrow A_x = 0$

$+\circlearrowleft \Sigma M_F = 0$ (why F?!)

$\Rightarrow -A_y(300+400+400) + W(400-100+400) = 0$

$A_y = \frac{7}{11} W$.

all dimensions in mm



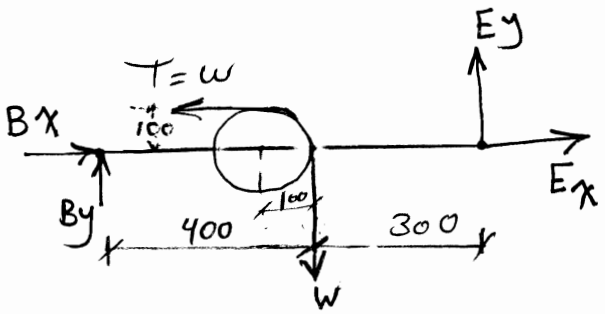
→ ?

Now, FBD ② (BDE with the pulley): (why ?!)

$+\circlearrowleft \sum M_E = 0$ (why E ?!)

$W(300) + W(100) - B_y(700) = 0$

$\Rightarrow B_y = \frac{4}{7} W$



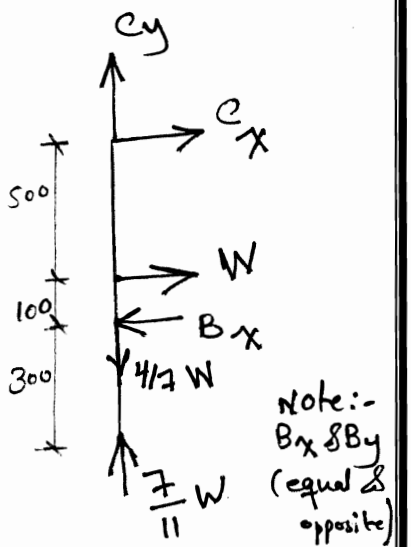
FBD ② "all in mm".

Then FBD ③ (ABC)

$+\circlearrowleft \sum M_C = 0$ (why ?!)

$\Rightarrow W(500) - B_x(600) = 0$

$\Rightarrow B_x = \frac{5}{6} W$.



Note:- Bx & By (equal & opposite)

FBD ③

We need to take the resultant of B. (why ?!)

$B = \sqrt{B_x^2 + B_y^2} = \sqrt{(\frac{5}{6})^2 + (\frac{4}{7})^2}\ W$

$\simeq 1.0104\ W$

Now, we set $B \equiv 24 \Rightarrow$

$1.0104\ W = 24 \Rightarrow W_{max} = 23.75\ KN$

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Problem 4:-

- Given :-
  . The figure shown
    Fig. P4
  . $F_{DE} = 800\ N$.
  . $\alpha = 80^\circ$

- Required :-
. the Horizontal force at A.

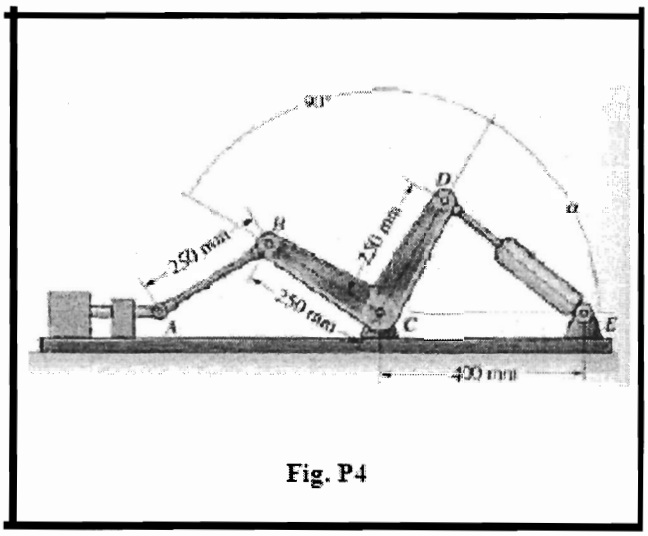


Fig. P4

- Solution :-

The FBD of BCD is drawn. (why?!)
Note that AB and DE are two-force members. (why?!)
f_{DE} is shown as "C". Could it be "T" ?!

$X_D = 250 \cos 80$
$= 43.412\ mm$

$y_D = 250 \sin 80 = 246.20\ mm$

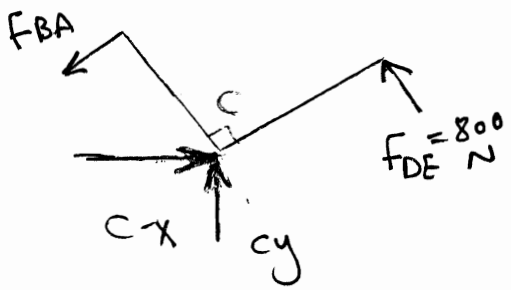
$|X_B| = 250 \cos 10$
$= 246.20\ mm$

$y_B = 250 \sin 10$
$= 43.412\ mm$

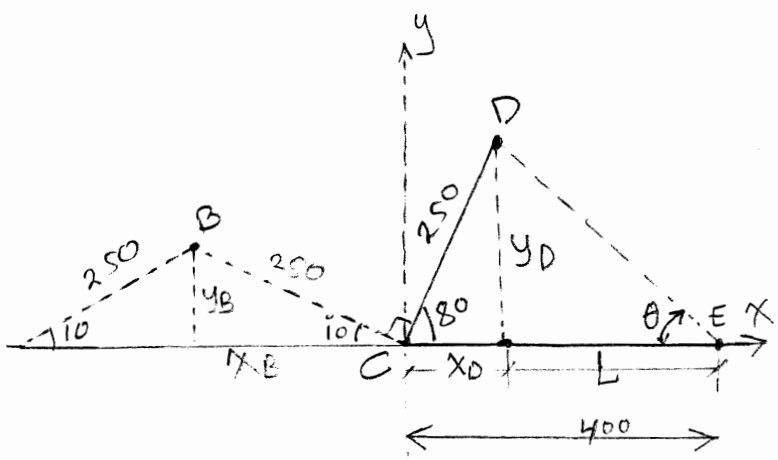
$L = 400 - X_D$
$= 356.59\ mm$

$\tan\theta = \frac{y_D}{L} = \frac{246.20}{356.59}$

$\Rightarrow \theta = 34.622^\circ$



FBD



Geometry.

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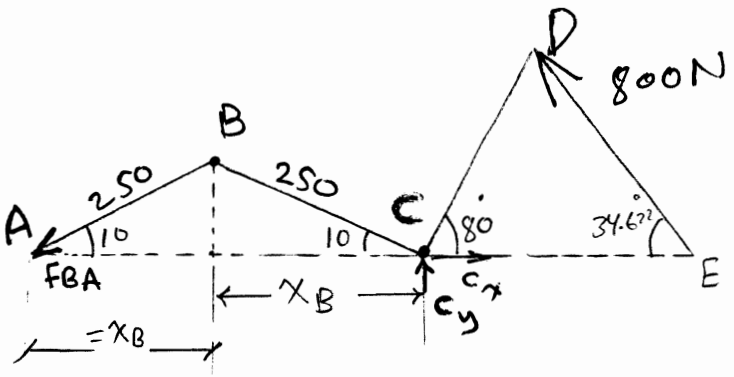
$$+\circlearrowleft \sum M_c = 0 = 800 \sin 34.622 (400) + F_{BA} \sin 10 (2 * 246.20)$$

$$\Rightarrow F_{BA} = -2126.4\ N = 2126.4\ N \nearrow \text{"C"}$$



The horizontal component of f_{BA} is

$$F_x^A = f_{BA} \cos 10^\circ$$

$$\Rightarrow \boxed{F_x^A = 2094\ N}$$

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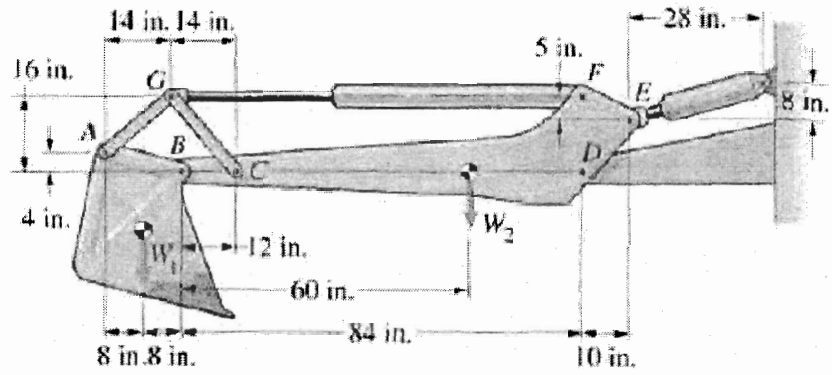


Fig. P5

Problem 5:

-Given:

. The figure shown above (fig. P5)

· $W_1 = 1500$ lb , $W_2 = 2000$ lb.

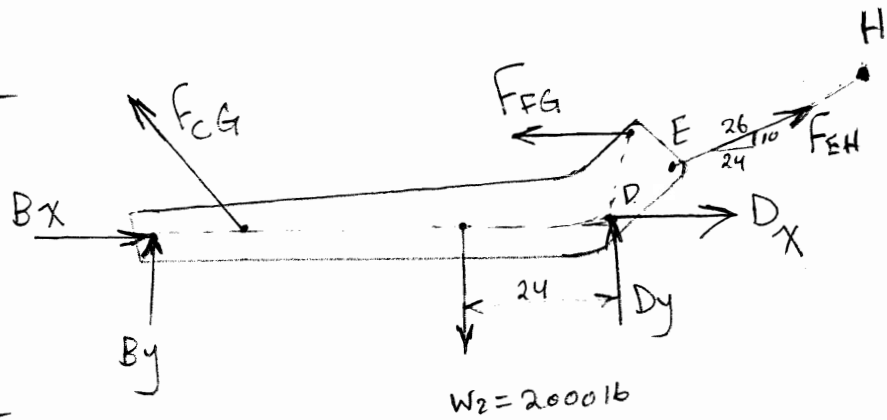
- Required:

. The forces on member BCD.

- Solution:-

The FBD of member BCD is drawn as shown.

Note that CG, EH, and FG are two-force members.



FBD ①

Also, note that in FBD①, there are 7 unknowns (and only 3 equations). Thus, we can not start with it.

→

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Take AB (bottom left part).

FBD ② is drawn.

$+\circlearrowleft \sum M_B = 0$ (why ?!)

$$1500(8) - \frac{14}{\sqrt{340}} F_{AG}(4) - \frac{12}{\sqrt{340}} F_{AG}(16) = 0$$

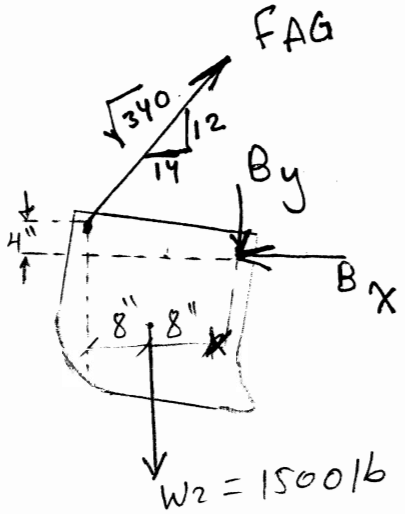
$$\Rightarrow F_{AG} = 892.21 \text{ lb}$$

$$\xrightarrow{+} \sum F_x = 0 \Rightarrow -B_x + \frac{14}{\sqrt{340}}(892.21) = 0$$

$$\Rightarrow B_x = 677.42 \text{ lb} \quad (\leftarrow)$$

$$+\uparrow \sum F_y = 0 \Rightarrow -1500 - B_y + \frac{12}{\sqrt{340}}(892.21) = 0$$

$$\Rightarrow B_y = -919.36 \text{ lb} = 919.36 \text{ lb} \uparrow$$



FBD ②

$\Rightarrow$ In member BCD, $\vec{B}$ is equal & opposite $\Rightarrow$

$B_x = 677.4$ lb $\rightarrow$

$B_y = 919.4$ lb $\downarrow$

We still have 5 unknowns in FBD ① (BCD).

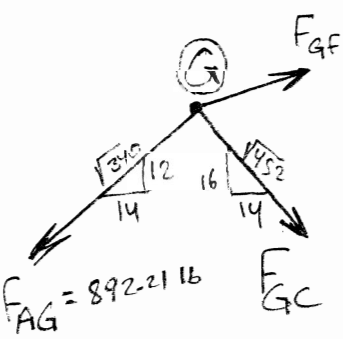
At point G, all members connected are two-force members. It has 1 known force (F_{AG}) and two unknowns.

$\Rightarrow$ we can solve. $\Rightarrow$ FBD ③

$+\uparrow \sum F_y = 0$ (why start with it ?!)

$$-892.21\left(\frac{12}{\sqrt{340}}\right) - F_{GC}\left(\frac{16}{\sqrt{452}}\right) = 0$$

$$\Rightarrow F_{GC} = -771.54 \text{ lb} = 771.54 \text{ lb} \text{ "C"}$$



$\pm \rightarrow \Sigma F_x = 0 \Rightarrow F_{GF} - 892.21\left(\frac{14}{\sqrt{340}}\right) \ominus 771.54\left(\frac{14}{\sqrt{452}}\right) = 0$

$\Rightarrow F_{GF} = 1185.5 \text{ lb } (\rightarrow)$ "T"

On BCD,

$f_{CG} = 771.54 \text{ lb} \searrow$ "C"

$f_{FG} = 1185.5 \text{ lb} \leftarrow$ "T"

Now, we come back to FBD① ($\underline{3}$ remaining unknowns only). $\Rightarrow$

$+\circlearrowleft \Sigma M_D = 0 = 2000(24) - F_{EH}\left(\frac{24}{26}\right)(11) + F_{EH}\left(\frac{10}{26}\right)(10)$

$+ 1185.5(16) + 919.36(84) + 771.54\left(\frac{16}{\sqrt{452}}\right)(72)$

$\Rightarrow F_{EH} = 29,488 \text{ lb} \nearrow$ "T"

$\pm \rightarrow \Sigma F_x = 0 = D_x + 677.42 + 771.54\left(\frac{14}{\sqrt{452}}\right) - 1185.5$

$+ 29,488\left(\frac{24}{26}\right) \Rightarrow D_x = -27,220 \text{ lb} = 27,220 \text{ lb} \leftarrow$

$+\uparrow \Sigma f_y = 0 = D_y - 2000 - 919.36 - 771.54\left(\frac{16}{\sqrt{452}}\right) + 29488\left(\frac{10}{26}\right)$

$\Rightarrow D_y = -7,842 \text{ lb} = 7,842 \text{ lb} \downarrow$

The values for these forces can be presented on FBD① (BCD) as drawn in previous problems.

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