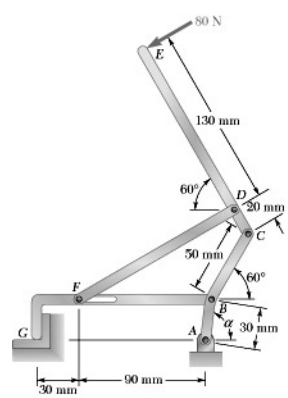
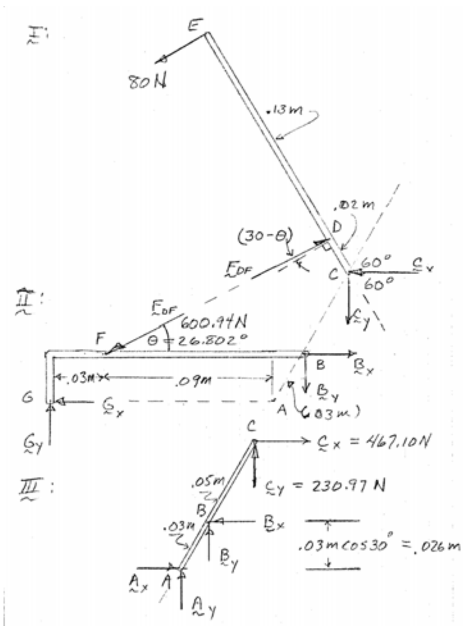
PROBLEM 6.122



The double toggle latching mechanism shown is used to hold member *G* against the support. Knowing that $\alpha = 60°$, determine the force exerted on *G*.

SOLUTION

member FBDs:



Note: $$\tan\theta = \frac{(0.05\text{ m} + 0.02\text{ m})\sin 60°}{(0.09\text{ m}) + \left[(0.03 + 0.05 - 0.02)\text{m}\right]\cos 60°}$$

$$= 0.50518$$

$$\theta = 26.802°$$

FBD I:

$$\circlearrowleft \Sigma M_C = 0\text{: } (0.15\text{ m})80\text{ N} - (0.02\text{ m})F_{DF}\cos(30° - 26.802°) = 0$$

$$F_{DF} = 600.94\text{ N}$$

$$\xrightarrow{\quad} \Sigma F_x = 0\text{: } (600.94\text{ N})\cos 26.802° - (80\text{ N})\sin 60° - C_x = 0$$

$$C_x = 467.10\text{ N}$$

$$\uparrow \Sigma F_y = 0\text{: } -C_y + (600.94\text{ N})\sin 26.802° - (80\text{ N})\cos 60° = 0$$

$$C_y = 230.97\text{ N}$$

FBD II:

$$\circlearrowleft \Sigma M_G = 0\text{: } \left[(0.03\text{ m})(\cos 30°)\right]B_x$$

$$+\left[0.12\,\text{m} + (0.03\,\text{m})\cos 60°\right]B_y$$

$$+(0.03\text{ m})\left[(600.94\text{ N})\sin 26.802°\right]$$

$$-(.026\text{ m})\left[(600.94\text{ N})\cos 26.802°\right] = 0$$

$$0.015\sqrt{3}B_x + 0.135B_y = 5.8065\text{ N} \qquad (1)$$

PROBLEM 6.122 CONTINUED

FBD III:

$$\circlearrowleft \Sigma M_A = 0: \left[(0.03\text{m})(\sin 60°)\right]B_x + \left[(0.03\text{ m})(\cos 60°)\right]B_y$$

$$-\left[(0.08\text{ m})(\sin 60°)\right]467.10\text{ N}$$

$$+\left[(0.08\text{ m})(\cos 60°)\right]230.97\text{ N} = 0$$

$$0.015\sqrt{3}B_x + 0.015B_y = 23.123\text{ N} \qquad (2)$$

Solving (1) and (2) $\qquad B_x = 973.31\text{ N}$

$$B_y = -144.303\text{ N}$$

FBD II:

$$\xrightarrow{+} \Sigma F_x = 0: -G_x - (600.94\text{ N})\cos 26.802° + 973.31\text{ N} = 0$$

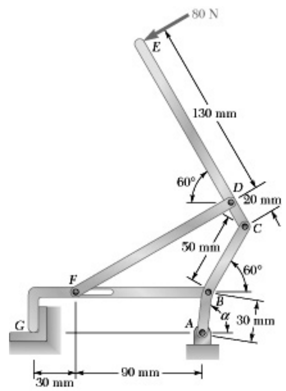
$$\mathbf{G}_x = 436.93\text{ N} \longleftarrow$$

$$+\!\uparrow \Sigma F_y = 0: -(-144.303\text{ N}) + G_y - (600.94\text{ N})\sin 26.802° = 0$$

$$\mathbf{G}_y = 126.67\text{ N}\uparrow$$

Therefore, the force acting on member G is $\qquad \mathbf{G} = 455\text{ N} \searrow 16.17°$ ◀

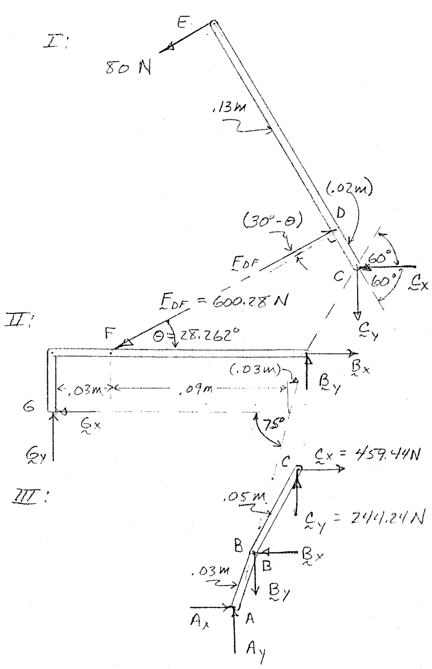
PROBLEM 6.123



The double toggle latching mechanism shown is used to hold member G against the support. Knowing that $\alpha = 75°$, determine the force exerted on G.

SOLUTION

FBDs:



Note: $$\tan\theta = \frac{(0.07\text{ m})\cos 30°}{0.09\text{ m} + (0.03\text{ m})\cos 75° + (0.03\text{ m})\sin 30°}$$

$$\theta = 28.262°$$

FBD I:

$$\circlearrowleft \Sigma M_C = 0\text{: } (0.15\text{ m})(80\text{ N}) - (0.02\text{ m})\, F_{DF}\cos(30° - 28.262°) = 0$$

$$F_{DF} = 600.28\text{ N}$$

$$\xrightarrow{} \Sigma F_x = 0\text{: } -C_x - (80\text{ N})\cos 30° + (600.28\text{ N})\cos 28.262° = 0$$

$$C_x = 459.44\text{ N}$$

$$\uparrow \Sigma F_y = 0\text{: } -C_y - (80\text{ N})\sin 30° - (600.28\text{ N})\sin 28.262° = 0$$

$$C_y = 244.24\text{ N}$$

FBD II:

$$\circlearrowleft \Sigma M_G = 0\text{: } -\left[(0.03\text{m})\sin 75°\right]B_x + \left[0.120\text{ m} + (0.03\text{m})\cos 75°\right]B_y$$

$$+\left[(0.03\text{ m})\sin 75°\right]\left[(600.28\text{ N})\cos 28.262°\right]$$

$$-(0.03\text{ m})\left[(600.28\text{ N})\sin 28.262°\right] = 0$$

$$0.9659B_x - 4.2588B_y = 226.47\text{ N} \qquad (1)$$

PROBLEM 6.123 CONTINUED

FBD III:

$$\circlearrowleft \Sigma M_A = 0: \left[(0.03\text{ m})\sin 75°\right]B_x - \left[(0.03\text{ m})\cos 75°\right]B_y$$

$$-\left[(0.03m)\sin 75° + (0.05\text{ m})\sin 60°\right](459.44\text{ N})$$

$$+\left[(0.03\text{ m})\cos 75° + (0.05\text{ m})\cos 60°\right](244.24\text{ N}) = 0$$

$$0.9659B_x - 0.2588B_y = 840.18\text{ N} \qquad (2)$$

Solving (1) and (2): $B_x = 910.93\text{ N}$

$B_y = 153.428\text{ N}$

FBD II:

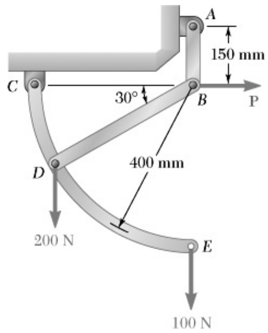
$$\xrightarrow{} \Sigma F_x = 0: \ -G_x - (600.28\text{ N})\cos 28.262° + 910.93\text{ N} = 0$$

$$\mathbf{G}_x = 382.21\text{ N} \longleftarrow$$

$$\uparrow \Sigma F_y = 0: G_y - (600.28\text{ N})\sin 28.262° + 153.428\text{ N} = 0$$

$$\mathbf{G}_y = 130.81\text{ N} \uparrow$$

Therefore, the force acting on member G is: $\mathbf{G} = 404\text{ N} \searrow 18.89°$ ◀

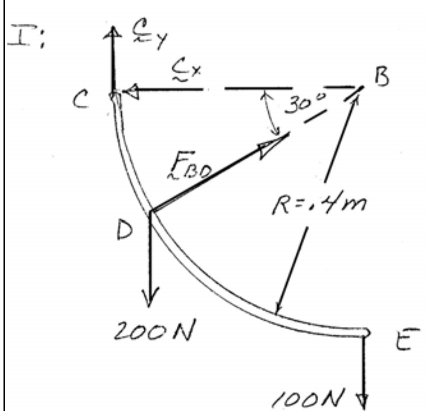


PROBLEM 6.124

For the system and loading shown, determine (*a*) the force **P** required for equilibrium, (*b*) the corresponding force in member *BD*, (*c*) the corresponding reaction at *C*.

SOLUTION

member FBDs:



FBD I :

$$\circlearrowright \Sigma M_C = 0: R\left(F_{BD}\sin 30°\right)$$

$$-\left[R\left(1-\cos 30°\right)\right]\left(200\text{ N}\right) - R\left(100\text{ N}\right) = 0$$

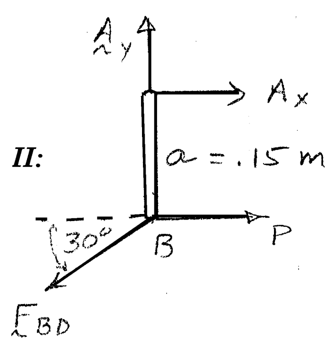
$F_{BD} = 253.6\text{ N}$ $\qquad$ $F_{BD} = 254\text{ N T}$ ◀

$$\xrightarrow{} \Sigma F_x = 0: \ -C_x + \left(253.6\text{ N}\right)\cos 30° = 0$$

$\mathbf{C}_x = 219.6\text{ N} \longleftarrow$

$$\uparrow \Sigma F_y = 0: C_y + \left(253.6\text{ N}\right)\sin 30° - 200\text{ N} - 100\text{ N} = 0$$

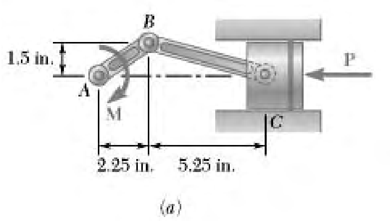
$\mathbf{C}_y = 173.2\text{ N} \uparrow$ $\qquad$ so $\mathbf{C} = 280\text{ N} \nwarrow 38.3°$ ◀

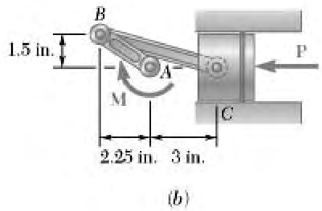


FBD II : $\circlearrowright \Sigma M_A = 0: aP - a\left[\left(253.6\text{ N}\right)\cos 30°\right] = 0$

$\mathbf{P} = 220\text{ N} \longrightarrow$ ◀

PROBLEM 6.125

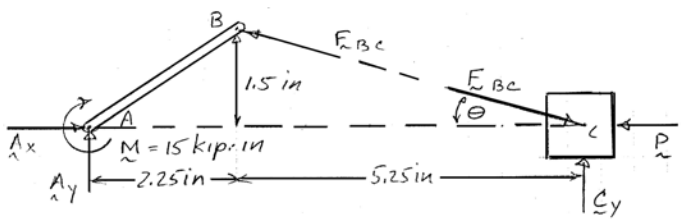




A couple **M** of magnitude $15 \text{ kip} \cdot \text{in.}$ is applied to the crank of the engine system shown. For each of the two positions shown, determine the force **P** required to hold the system in equilibrium.

SOLUTION

(a) **FBDs:**



Note: $\tan\theta = \dfrac{1.5 \text{ in.}}{5.25 \text{ in.}}$

$$= \frac{2}{7}$$

FBD whole: $\circlearrowleft \Sigma M_A = 0\text{: } (7.50 \text{ in.})C_y - 15 \text{ kip} \cdot \text{in.} = 0 \qquad C_y = 2.00 \text{ kips}$

FBD piston: $\uparrow \Sigma F_y = 0\text{: } C_y - F_{BC}\sin\theta = 0 \qquad F_{BC} = \dfrac{C_y}{\sin\theta} = \dfrac{2 \text{ kips}}{\sin\theta}$

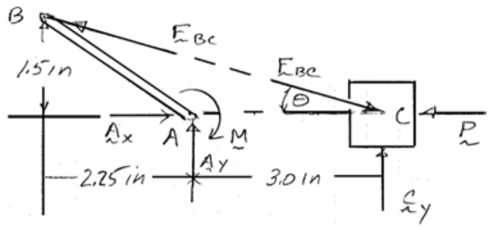
$$\longrightarrow \Sigma F_x = 0\text{: } F_{BC}\cos\theta - P = 0$$

$$P = F_{BC}\cos\theta = \frac{2 \text{ kips}}{\tan\theta} = 7 \text{ kips}$$

$\mathbf{P} = 7.00 \text{ kips} \longleftarrow$ ◀

PROBLEM 6.125 CONTINUED

(*b*) **FBDs:**



Note: $\tan\theta = \dfrac{2}{7}$ as above

FBD whole: $\circlearrowleft \Sigma M_A = 0: (3\text{ in.})C_y - 15\text{ kip}\cdot\text{in.} = 0 \qquad C_y = 5\text{ kips}$

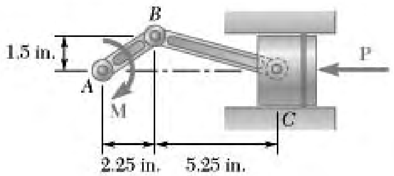
$$\Sigma F_y = 0: C_y - F_{BC}\sin\theta = 0 \qquad F_{BC} = \frac{C_y}{\sin\theta}$$

$$\longrightarrow \Sigma F_x = 0: F_{BC}\cos\theta - P = 0$$

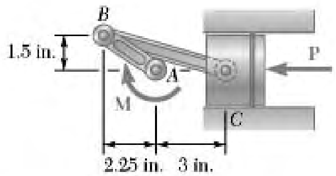
$$P = F_{BC}\cos\theta = \frac{C_y}{\tan\theta} = \frac{5\text{ kips}}{2/7}$$

$\mathbf{P} = 17.50\text{ kips} \longleftarrow$ ◀

PROBLEM 6.126



(a)

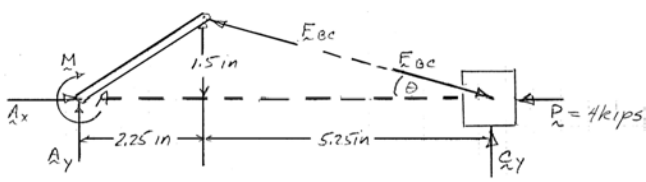


(b)

A force **P** of magnitude 4 kips is applied to the piston of the engine system shown. For each of the two positions shown, determine the couple **M** required to hold the system in equilibrium.

SOLUTION

(*a*) **FBDs:**



Note: $\tan\theta = \dfrac{1.5 \text{ in.}}{5.25 \text{ in.}}$

$$= \frac{2}{7}$$

FBD piston: $\xrightarrow{} \Sigma F_x = 0: F_{BC}\cos\theta - P = 0 \qquad F_{BC} = \dfrac{P}{\cos\theta}$

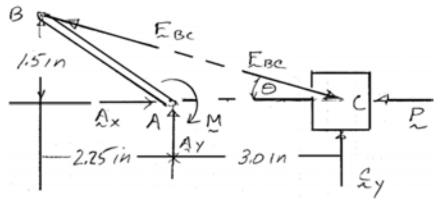
$$\uparrow \Sigma F_y = 0: C_y - F_{BC}\sin\theta = 0 \qquad C_y = F_{BC}\sin\theta = P\tan\theta = \frac{2}{7}P$$

FBD whole: $\circlearrowleft \Sigma M_A = 0: (7.50 \text{ in.})C_y - M = 0 \qquad M = 7.5 \text{ in.} \qquad C_y = \dfrac{15 \text{ in.}}{7}P$

$$\mathbf{M} = 8.57 \text{ kip} \cdot \text{in.} \circlearrowright \blacktriangleleft$$

PROBLEM 6.126 CONTINUED

(*b*) **FBDs:**



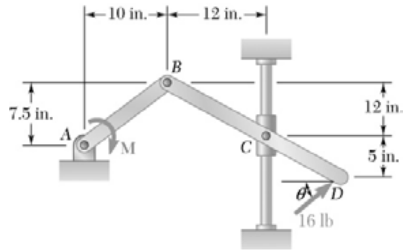
Note: $\tan\theta = \dfrac{2}{7}$ as above

FBD piston: as above $C_y = P\tan\theta = \dfrac{2}{7}P$

FBD whole: $\Sigma M_A = 0: \ (3.0\text{ in.})C_y - M = 0 \qquad M = (3.0\text{ in.})\dfrac{2}{7}P$

$$M = \frac{24}{7}\text{ kip}\cdot\text{in.} \qquad \mathbf{M} = 3.43\text{ kip}\cdot\text{in.} \ ◀$$

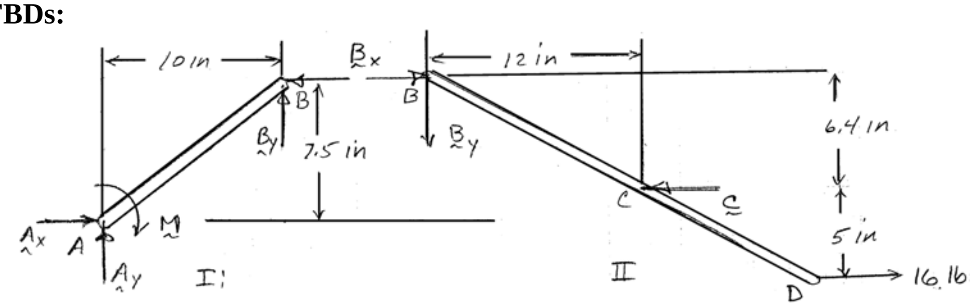
PROBLEM 6.127



Arm *BCD* is connected by pins to crank *AB* at *B* and to a collar at *C*. Neglecting the effect of friction, determine the couple **M** required to hold the system in equilibrium when $\theta = 0$.

SOLUTION

member FBDs:



FBD II: $\uparrow \Sigma F_y = 0: B_y = 0$

$\circlearrowleft \Sigma M_C = 0: \ (6.4 \text{ in.})B_x - (5 \text{ in.})16 \text{ lb} = 0 \qquad B_x = 12.5 \text{ lb}$

FBD I: $\circlearrowleft \Sigma M_A = 0: \ (7.5 \text{ in.})B_x - M = 0 \qquad M = (7.5 \text{ in.})(12.5 \text{ lb}) = 93.8 \text{ lb}\cdot\text{in.}$

$\mathbf{M} = 93.8 \text{ lb}\cdot\text{in.} \circlearrowright$ ◀