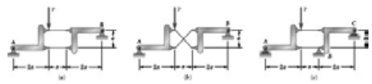
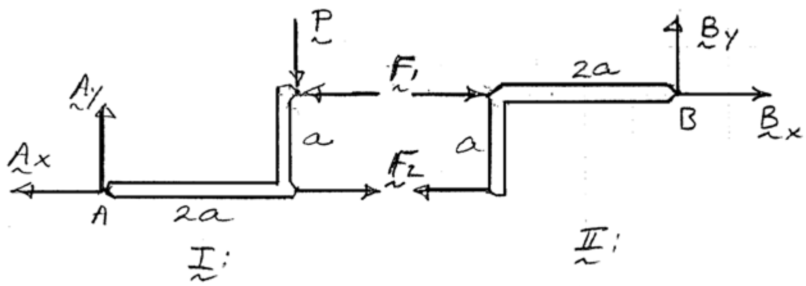


PROBLEM 6.115

Each of the frames shown consists of two L-shaped members connected by two rigid links. For each frame, determine the reactions at the supports and indicate whether the frame is rigid.

SOLUTION

(*a*) **member FBDs:**



FBD I: $\circlearrowleft \Sigma M_A = 0: aF_1 - 2aP = 0 \qquad F_1 = 2P; \uparrow \Sigma F_y = 0: A_y - P = 0 \qquad \mathbf{A}_y = P \uparrow$

FBD II: $\circlearrowleft \Sigma M_B = 0: \ -aF_2 = 0 \qquad F_2 = 0$

$\longrightarrow \Sigma F_x = 0: B_x + F_1 = 0, \ \ B_x = -F_1 = -2P \qquad \mathbf{B}_x = 2P \longrightarrow$

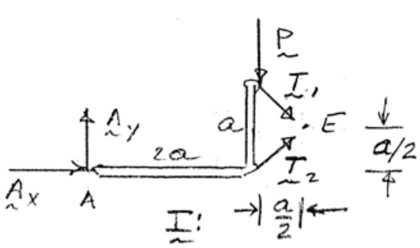
$\uparrow \Sigma F_y = 0: \ B_y = 0$ so $\mathbf{B} = 2P \longrightarrow$ ◀

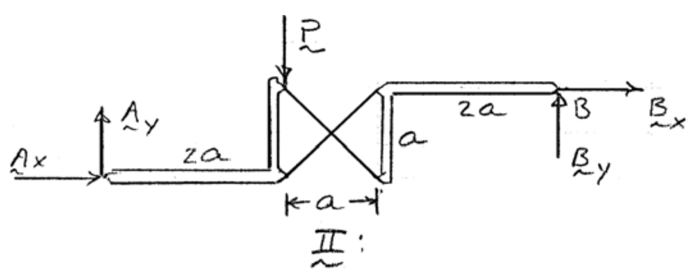
FBD I: $\longrightarrow \Sigma F_x = 0: \ -A_x - F_1 + F_2 = 0 \qquad A_x = F_2 - F_1 = 0 - 2P \qquad \mathbf{A}_x = 2P \longrightarrow$

so $\mathbf{A} = 2.24P \measuredangle 26.6°$ ◀

frame is rigid ◀

(*b*) **FBD left:** **FBD whole:**





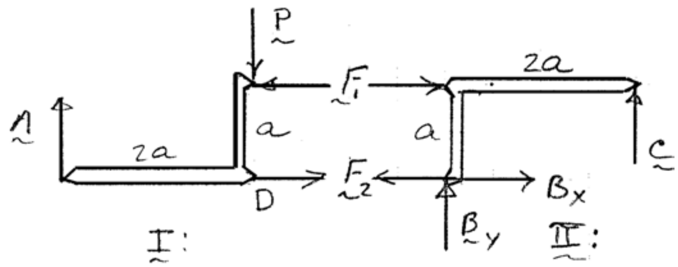
FBD I: $\circlearrowleft \Sigma M_E = 0: \dfrac{a}{2}P + \dfrac{a}{2}A_x - \dfrac{5a}{2}A_y = 0 \qquad A_x - 5A_y = -P$

FBD II: $\circlearrowleft \Sigma M_B = 0: 3aP + aA_x - 5aA_y = 0 \qquad A_x - 5A_y = -3P$

This is impossible unless $P = 0 \quad \therefore$ not rigid ◀

PROBLEM 6.115 CONTINUED

(c) **member FBDs:**



FBD I: $\Sigma F_y = 0: A - P = 0$ $\qquad$ $\mathbf{A} = P \uparrow$ ◀

$\circlearrowleft \Sigma M_D = 0: aF_1 - 2aA = 0 \qquad F_1 = 2P$

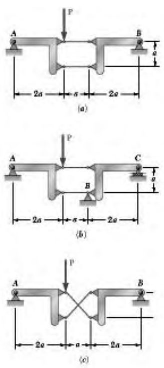
$\rightarrow \Sigma F_x = 0: F_2 - F_1 = 0 \qquad F_2 = 2P$

FBD II: $\circlearrowleft \Sigma M_B = 0: 2aC - aF_1 = 0 \qquad C = \dfrac{F_1}{2} = P$ $\qquad$ $\mathbf{C} = P \uparrow$ ◀

$\rightarrow \Sigma F_x = 0: F_1 - F_2 + B_x = 0 \qquad B_x = P - P = 0$

$\uparrow \Sigma F_x = 0: B_y + C = 0 \qquad B_y = -C = -P$ $\qquad$ $\mathbf{B} = P$ ◀

Frame is rigid ◀

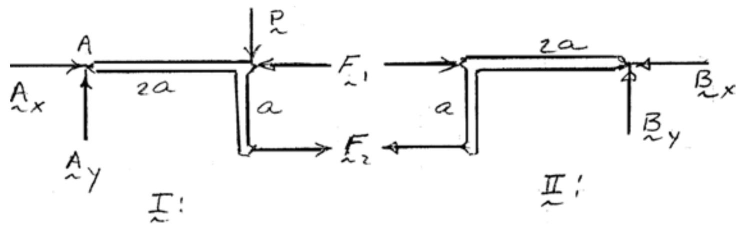


PROBLEM 6.116

Each of the frames shown consists of two L-shaped members connected by two rigid links. For each frame, determine the reactions at the supports and indicate whether the frame is rigid.

SOLUTION

(*a*) **member FBDs:**

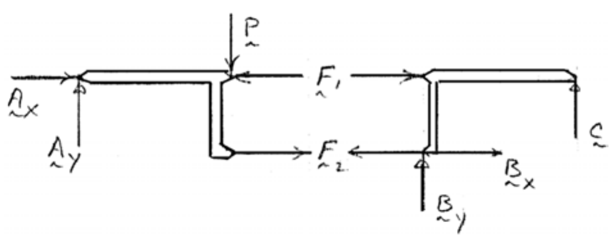


FBD II: $\uparrow \Sigma F_y = 0: B_y = 0$ $\quad \circlearrowleft \Sigma M_B = 0: aF_2 = 0$ $\quad F_2 = 0$

FBD I: $\circlearrowleft \Sigma M_A = 0: aF_2 - 2aP = 0$ $\quad$ but $F_2 = 0$

so $P = 0$ $\quad$ not rigid for $P \neq 0$ ◀

(*b*) **member FBDs:**

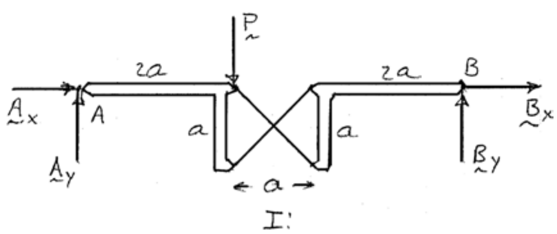


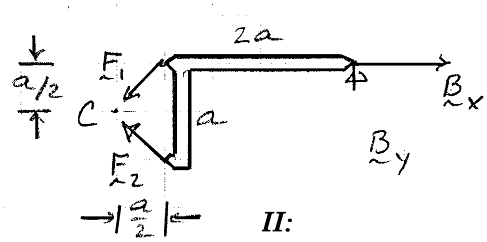
Note: 7 unknowns $\left(A_x, A_y, B_x, B_y, F_1, F_2, C\right)$ but only 6 independent equations.

System is statically indeterminate ◀

System is, however, rigid ◀

(*c*) **FBD whole:** **FBD right:**





PROBLEM 6.116 CONTINUED

FBD I: $\circlearrowright \Sigma M_A = 0: 5aB_y - 2aP = 0 \qquad \mathbf{B}_y = \frac{2}{5}P \uparrow$

$\uparrow \Sigma F_y = 0: A_y - P + \frac{2}{5}P = 0 \qquad \mathbf{A}_y = \frac{3}{5}P \uparrow$

FBD II: $\circlearrowleft \Sigma M_c = 0: \frac{a}{2}B_x - \frac{5a}{2}B_y = 0 \qquad B_x = 5B_y \qquad \mathbf{B}_x = 2P \longrightarrow$

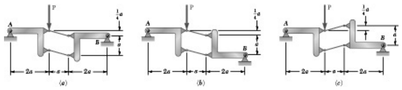
FBD I: $\longrightarrow \Sigma F_x = 0: A_x + B_x = 0 \qquad A_x = -B_x \qquad \mathbf{A}_x = 2P \longleftarrow$

$\mathbf{A} = 2.09P \searrow 16.70°$ ◀

$\mathbf{B} = 2.04P \nearrow 11.31°$ ◀

System is rigid ◀

PROBLEM 6.117

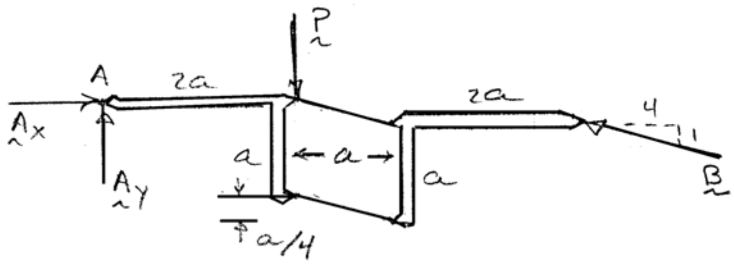


Each of the frames shown consists of two L-shaped members connected by two rigid links. For each frame, determine the reactions at the supports and indicate whether the frame is rigid.

SOLUTION

Note: In all three cases, the right member has only three forces acting, two of which are parallel. Thus the third force, at *B*, must be parallel to the link forces.

(*a*) **FBD whole:**



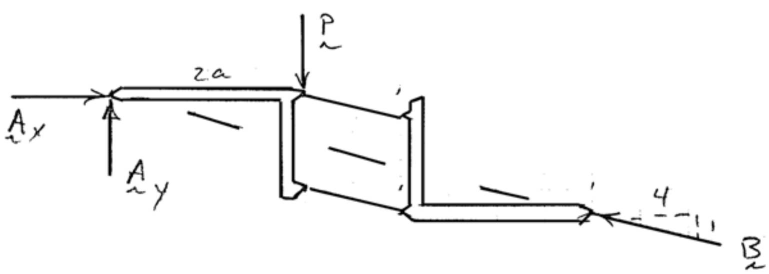
$$\circlearrowleft \Sigma M_A = 0: \; -2aP - \frac{a}{4}\frac{4}{\sqrt{17}}B + 5a\frac{1}{\sqrt{17}}B = 0 \qquad B = 2.06P \qquad \mathbf{B} = 2.06P \;\searrow\; 14.04° \blacktriangleleft$$

$$\longrightarrow \Sigma F_x = 0: \; A_x - \frac{4}{\sqrt{17}}B = 0 \qquad \mathbf{A}_x = 2P \longleftarrow$$

$$\uparrow \Sigma F_y = 0: \; A_y - P + \frac{1}{\sqrt{17}}B = 0 \qquad \mathbf{A}_y = \frac{P}{2} \uparrow \qquad \mathbf{A} = 2.06P \;\angle\; 14.04° \blacktriangleleft$$

rigid ◀

(*b*) **FBD whole:**

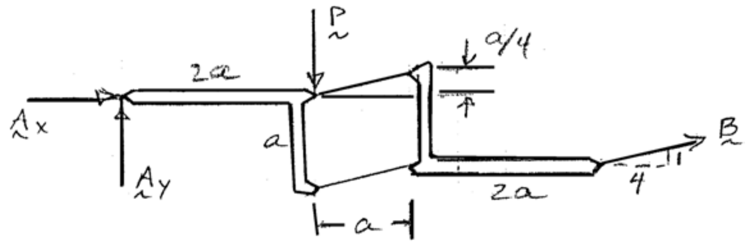


Since **B** passes through *A*, $\circlearrowleft \Sigma M_A = 2aP = 0$ only if $P = 0$

$\therefore$ no equilibrium if $P \neq 0$ not rigid ◀

PROBLEM 6.117 CONTINUED

(*c*) **FBD whole:**



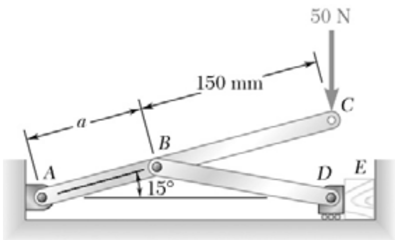
$\circlearrowleft \Sigma M_A = 0$: $5a\dfrac{1}{\sqrt{17}}B + \dfrac{3a}{4}\dfrac{4}{\sqrt{17}}B - 2aP = 0$ $\quad B = \dfrac{\sqrt{17}}{4}P$ $\quad$ **B** $= 1.031P \measuredangle 14.04°$ ◀

$\longrightarrow \Sigma F_x = 0$: $A_x + \dfrac{4}{\sqrt{17}}B = 0$ $\quad A_x = -P$

$\uparrow \Sigma F_y = 0$: $A_y - P + \dfrac{1}{\sqrt{17}}B = 0$ $\quad A_y = P - \dfrac{P}{4} = \dfrac{3P}{4}$ $\quad$ **A** $= 1.250P$ ⦪ $36.9°$ ◀

System is rigid ◀

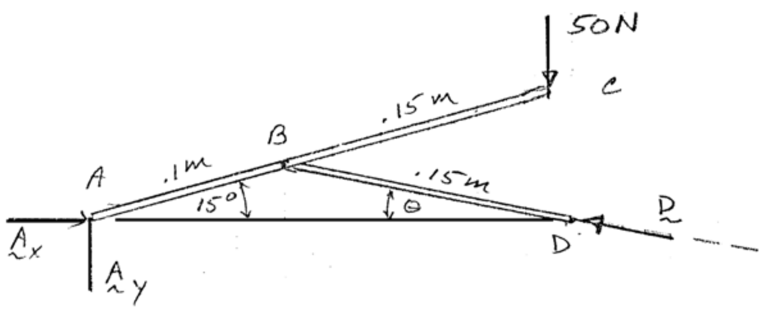
PROBLEM 6.118



A 50-N force directed vertically downward is applied to the toggle vise at C. Knowing that link BD is 150 mm long and that $a = 100$ mm, determine the horizontal force exerted on block E.

SOLUTION

FBD machine:



Note: $(0.1\text{ m})\sin 15° = (0.15\text{ m})\sin\theta$

$$\theta = \sin^{-1}(0.17255) = 9.9359°$$

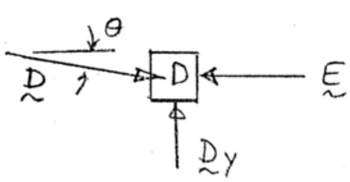
$$\widehat{AD} = (0.1\text{ m})\cos 15° + (0.15\text{ m})\cos\theta$$

$$= 0.24434\text{ m}$$

$$\circlearrowleft \Sigma M_A = 0\text{: } (0.24434\text{ m})D\sin\theta - (0.25\text{ m})(\cos 15°)(50\text{ N}) = 0$$

$$D = \frac{0.25\cos 15°}{(0.24434)(0.17255)} 50\text{ N} = 286.38\text{ N}$$

FBD part D :

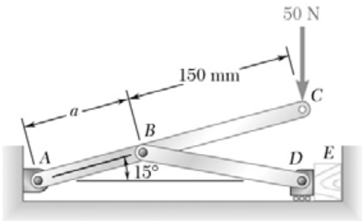


$$\xrightarrow{} \Sigma F_x = 0\text{: } D\cos\theta - E = 0$$

$$E = D\cos\theta = 282.1\text{ N}$$

$$\mathbf{E}_{\text{block}} = 282\text{ N} \longrightarrow \blacktriangleleft$$

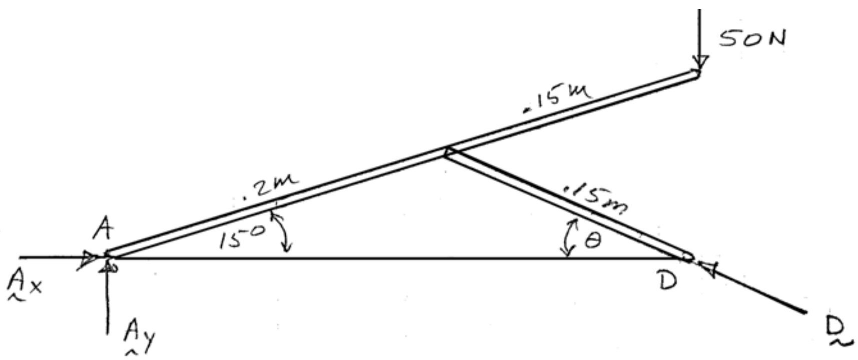
PROBLEM 6.119



A 50-N force directed vertically downward is applied to the toggle vise at C. Knowing that link BD is 150 mm long and that $a = 200$ mm, determine the horizontal force exerted on block E.

SOLUTION

FBD machine:



Note: $(0.2 \text{ m})\sin 15° = (0.15 \text{ m})\sin\theta$

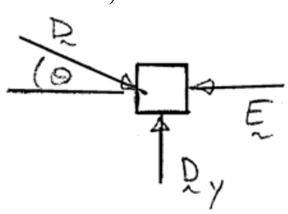
$$\theta = \sin^{-1}(0.3451) = 20.187°$$

$$\widehat{AD} = (0.2 \text{ m})\cos 15° + (0.15\text{m})\cos\theta$$

$$= 0.33397 \text{ m}$$

$$\circlearrowleft \Sigma M_A = 0\text{: } (0.33397 \text{ m})D \sin 20.187° - (0.35\text{m})(\cos 15°)(50 \text{ N}) = 0 \qquad D = 146.67 \text{ N}$$

FBD part D:

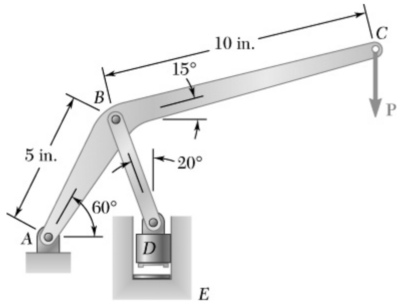


$$\xrightarrow{} \Sigma F_x = 0\text{: } D\cos\theta - E = 0$$

$$E = (146.67 \text{ N})\cos 20.187°$$

$$= 137.66 \text{ N}$$

$$\mathbf{E}_{\text{on block}} = 137.7 \text{ N} \longrightarrow \blacktriangleleft$$

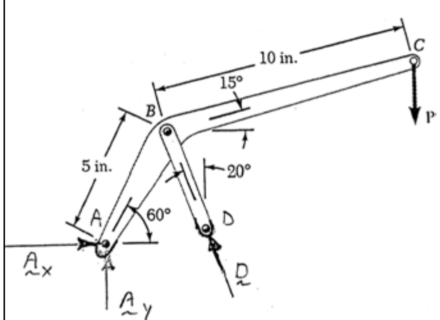


PROBLEM 6.120

The press shown is used to emboss a small seal at E. Knowing that $P = 60$ lb, determine (a) the vertical component of the force exerted on the seal, (b) the reaction at A.

SOLUTION

FBD machine:



$$\circlearrowleft \Sigma M_A = 0: \left[(5 \text{ in.})\cos 60°\right] D\cos 20° + \left[(5 \text{ in.})\sin 60°\right] D\sin 20°$$

$$-\left[(5 \text{ in.})\cos 60° + (10 \text{ in.})\cos 15°\right](60 \text{ lb}) = 0$$

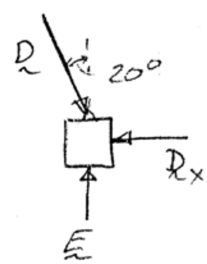
$$D = 190.473 \text{ lb}$$

$$\rightarrow \Sigma F_x = 0: A_x - D\sin 20° = 0 \qquad A_x = 65.146 \text{ lb}$$

$$\uparrow \Sigma F_y = 0: A_y + D\cos 20° - 60 \text{ lb} = 0 \qquad A_x = -118.99 \text{ lb}$$

so $\mathbf{A} = 135.7 \text{ lb} \searrow 61.3°$ ◀

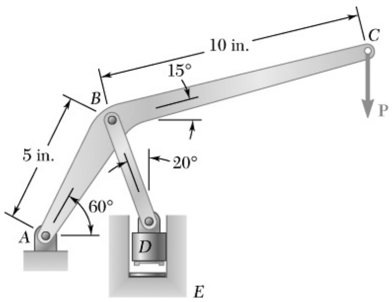
FBD part D:



$$\uparrow \Sigma F_y = 0: E - D\cos 20° = 0 \qquad E = (190.47 \text{ lb})\cos 20°$$

$$= 178.98 \text{ lb}$$

$$\mathbf{E}_{\text{on seal}} = 179.0 \text{ lb} \downarrow$$

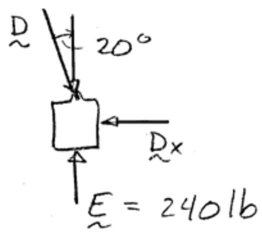


PROBLEM 6.121

The press shown is used to emboss a small seal at E. Knowing that the vertical component of the force exerted on the seal must be 240 lb, determine (a) the required vertical force **P**, (b) the corresponding reaction at A.

SOLUTION

FBD part D:

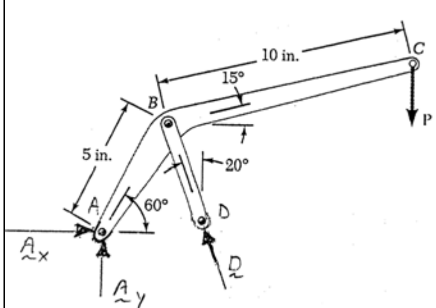


(a)

$$\uparrow \Sigma F_y = 0: E - D\cos 20° = 0$$

$$D = \frac{240 \text{ lb}}{\cos 20°} = 255.40 \text{ lb}$$

FBD machine:



$$\circlearrowleft \Sigma M_A = 0: \left[(5\text{in.})\cos 60°\right]D\cos 20° + \left[(5 \text{ in.})\cos 60°\right]D\sin 20°$$

$$-\left[(5\text{in.})\cos 60° + 10\text{in.})\cos 15°\right]P = 0$$

$$P = 80.453 \text{ lb}$$

$$\mathbf{P} = 80.5 \text{ lb} \downarrow \blacktriangleleft$$

(b)

$$\rightarrow \Sigma F_x = 0: A_x - D\sin 20° = 0$$

$$A_x = 87.35 \text{ lb}$$

$$\uparrow \Sigma F_y = 0: A_y + 240 \text{ lb} - 80.5 \text{ lb} = 0$$

$$A_y = 159.5 \text{ lb}$$

$$\mathbf{A} = 181.9 \text{ lb} \nwarrow 61.3° \blacktriangleleft$$