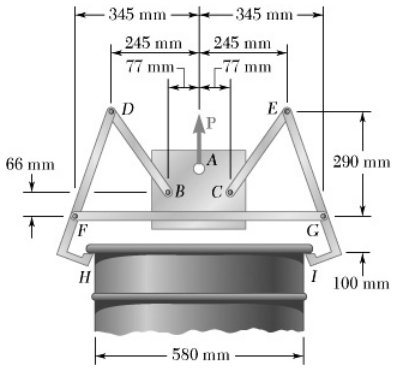
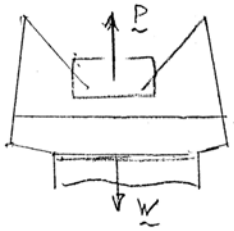


PROBLEM 6.137

The drum lifter shown is used to lift a steel drum. Knowing that the mass of the drum and its contents is 240 kg, determine the forces exerted at *F* and *H* on member *DFH*.

SOLUTION

FBD System:



$$\uparrow \Sigma F_y = 0;$$

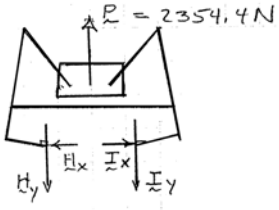
$$P - W = 0$$

$$P = W$$

$$= (240 \text{ kg})\left(9.81 \text{ m/s}^2\right)$$

$$P = 2354.4 \text{ N}$$

FBD machine:



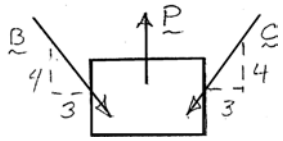
Symmetry: $H_x = I_x$

$$H_y = I_y$$

$$\uparrow \Sigma F_y = 0: P - 2H_y = 0$$

$$H_y = \frac{P}{2} = 1177.2 \text{ N}$$

FBD ABC:



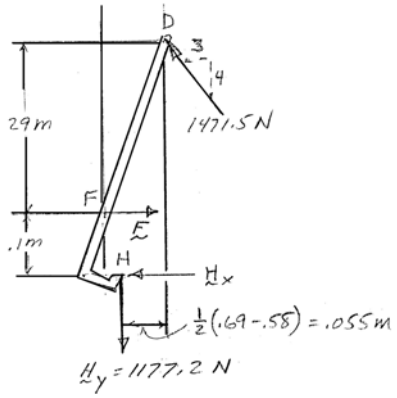
Symmetry: $C = B$

$$\Sigma F_y = 0: P - 2\frac{4}{5}B = 0$$

$$B = \frac{5}{8}P = 1471.5 \text{ N}$$

PROBLEM 6.137 CONTINUED

FBD DFH:



$$\circlearrowleft \Sigma M_H = 0: \; -(0.1\text{ m})F + (0.39\text{ m})\left(\frac{3}{5}1471.5\text{ N}\right)$$

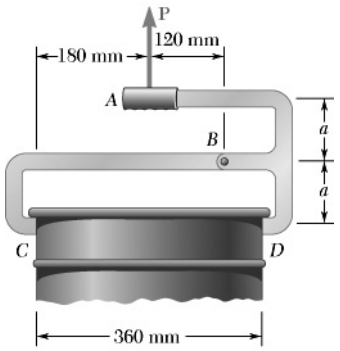
$$-(0.055\text{ m})\left(\frac{4}{5}1471.5\text{ N}\right) = 0$$

$$F = 3973.05\text{ N} \qquad \mathbf{F} = 3.97\text{ kN} \rightarrow \blacktriangleleft$$

$$\rightarrow \Sigma F_x = 0: 3973.05\text{ N} - \frac{3}{5}1471.5\text{ N} - H_x = 0$$

$$H_x = 3090.15\text{ N}$$

$$\mathbf{H} = 3.31\text{ kN} \measuredangle 20.9° \blacktriangleleft$$



PROBLEM 6.138

A small barrel having a mass of 72 kg is lifted by a pair of tongs as shown. Knowing that $a = 100$ mm, determine the forces exerted at *B* and *D* on tong *ABD*.

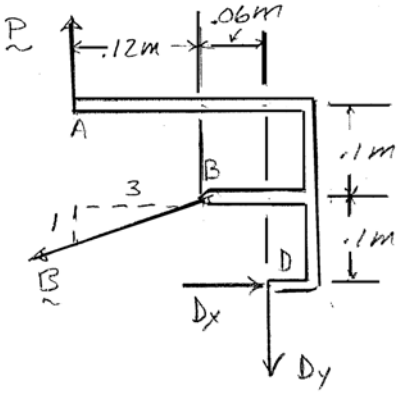
SOLUTION

Notes: From FBD whole, by inspection,

$$P = W = mg = (72\text{ kg})(9.81\text{ m/s}^2)$$

$$P = 706.32\text{ N}$$

FBB ABD:



BC is a two-force member: $B_x = 3B_y$

$$\circlearrowleft \Sigma M_D = 0: (0.1\text{ m})B_x + (0.06\text{ m})B_y - (0.18\text{ m})P = 0$$

$$3B_y + 0.6B_y = 1.8P$$

$$B_y = \frac{P}{2} = 353.16\text{ N}$$

so

$$B_x = \frac{3P}{2} = 1059.48\text{ N}$$

and $\mathbf{B} = 1.117\text{ kN} \measuredangle 18.43°$ ◀

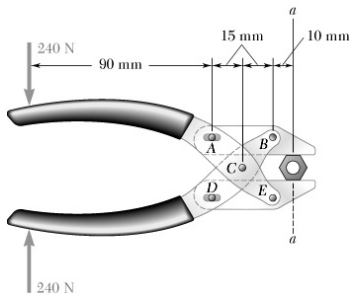
$$\rightarrow \Sigma F_x = 0: -B_x + D_x = 0$$

$$D_x = \frac{3P}{2} = 1059.48\text{ N}$$

$$\uparrow \Sigma F_y = 0: P - B_y - D_y = 0$$

$$D_y = P - \frac{P}{2} = 353.16\text{ N}$$

so $\mathbf{D} = 1.117\text{ kN} \measuredangle 18.43°$ ◀

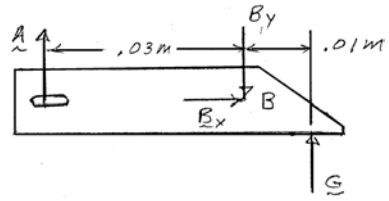


PROBLEM 6.139

Determine the magnitude of the ripping forces exerted along line *aa* on the nut when two 240-N forces are applied to the handles as shown. Assume that pins *A* and *D* slide freely in slots cut in the jaws.

SOLUTION

FBD jaw AB:



$$\rightarrow \Sigma F_x = 0: B_x = 0$$

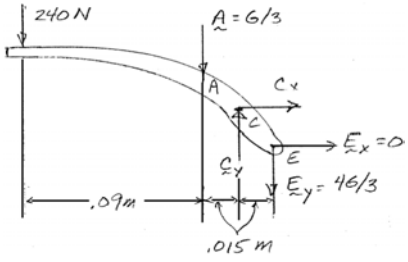
$$\circlearrowleft \Sigma M_B = 0: (0.01\text{ m})G - (0.03\text{ m})A = 0$$

$$A = \frac{G}{3}$$

$$\uparrow \Sigma F_y = 0: A + G - B_y = 0$$

$$B_y = A + G = \frac{4G}{3}$$

FBD handle ACE:

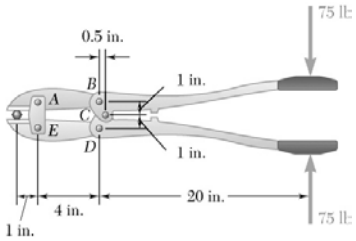


By symmetry and FBD jaw *DE*: $D = A = \frac{G}{3}, E_x = B_x = 0,$

$$E_y = B_y = \frac{4G}{3}$$

$$\circlearrowleft \Sigma M_C = 0: (0.105\text{ m})(240\text{ N}) + (0.015\text{ m})\frac{G}{3} - (0.015\text{ m})\frac{4G}{3} = 0$$

$$G = 1680\text{ N} \blacktriangleleft$$

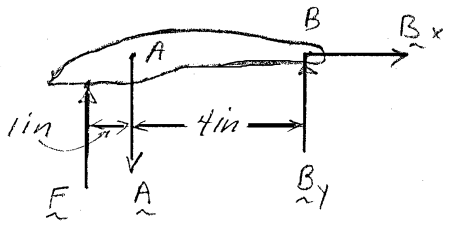


PROBLEM 6.140

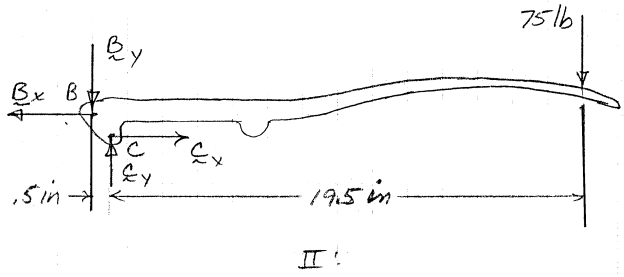
In using the bolt cutter shown, a worker applies two 75-lb forces to the handles. Determine the magnitude of the forces exerted by the cutter on the bolt.

SOLUTION

FBD Cutter AB:



FBD handle BC:



FBD I: $\rightarrow \Sigma F_x = 0$: $B_x = 0$

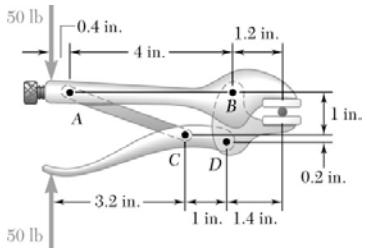
FBD II: $\circlearrowleft \Sigma M_C = 0$: $(0.5 \text{ in.})B_y - (19.5 \text{ in.})75 \text{ lb} = 0$

$B_y = 2925 \text{ lb}$

Then FBD I: $\circlearrowleft \Sigma M_A = 0$: $(4 \text{ in.})B_y - (1 \text{ in.})F = 0$ $\quad F = 4B_y$

$F = 11700 \text{ lb} = 11.70 \text{ kips}$ ◀

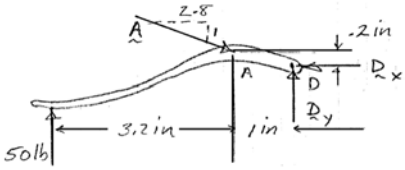
PROBLEM 6.141



Determine the magnitude of the gripping forces produced when two 50-lb forces are applied as shown.

SOLUTION

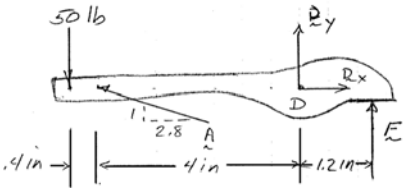
FBD handle CD:



$$\circlearrowleft \Sigma M_D = 0: \; -(4.2 \text{ in.})(50 \text{ lb}) - (0.2 \text{ in.})\frac{2.8}{\sqrt{8.84}}A + (1 \text{ in.})\left(\frac{1}{\sqrt{8.84}}A\right) = 0$$

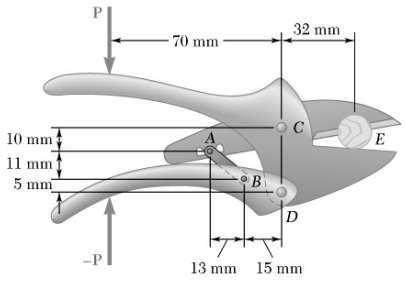
$$A = 477.27\sqrt{8.84} \text{ lb}$$

FBD handle AD:



$$\circlearrowleft \Sigma M_D = 0: \; (4.4 \text{ in.})(50 \text{ lb}) - (4 \text{ in.})\frac{1}{\sqrt{8.84}}\left(477.27\sqrt{8.84} \text{ lb}\right) + (1.2 \text{ in.})F = 0$$

$$F = 1.408 \text{ kips} \blacktriangleleft$$

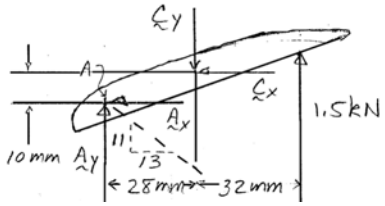


PROBLEM 6.142

The compound-lever pruning shears shown can be adjusted by placing pin *A* at various ratchet positions on blade *ACE*. Knowing that 1.5-kN vertical forces are required to complete the pruning of a small branch, determine the magnitude *P* of the forces that must be applied to the handles when the shears are adjusted as shown.

SOLUTION

FBD cutter AC:



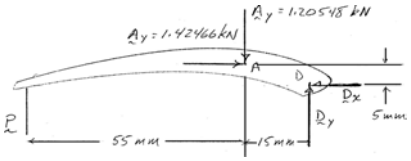
$$\circlearrowleft \Sigma M_C = 0: \ (32 \text{ mm})1.5 \text{ KN} - (28 \text{ mm})A_y - (10 \text{ mm})A_x = 0$$

$$10A_x + 28\left(\frac{11}{13}A_x\right) = 48 \text{ kN}$$

$$A_x = 1.42466 \text{ kN}$$

$$A_y = 1.20548 \text{ kN}$$

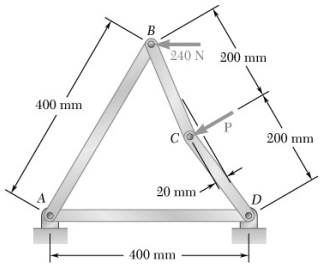
FBD handle AD:



$$\circlearrowleft \Sigma M_D = 0: \ (15 \text{ mm})(1.20548 \text{ kN}) - (5 \text{ mm})(1.42466 \text{ kN})$$

$$-(70 \text{ mm})P = 0$$

$$P = 0.1566 \text{ kN} = 156.6 \text{ N} \blacktriangleleft$$

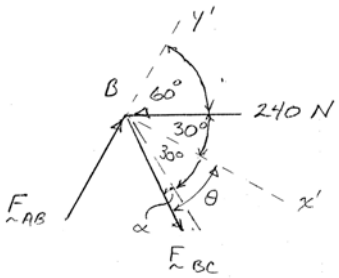


PROBLEM 6.143

Determine the force **P** which must be applied to the toggle *BCD* To maintain equilibrium in the position shown.

SOLUTION

FBD joint B:



Note: $\theta = 30° + \alpha$

$$= 30° + \tan^{-1}\frac{20}{200}$$

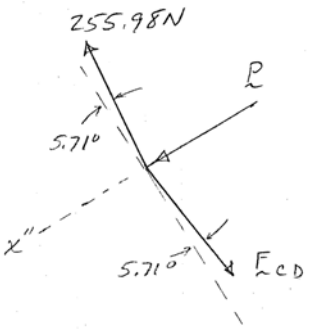
$$= 30° + 5.711°$$

$$= 35.711°$$

$$\searrow \Sigma F_{x'} = 0: F_{BC}\cos 35.711° - (240\text{ N})\cos 30° = 0$$

$$F_{BC} = 255.98\text{ N T}$$

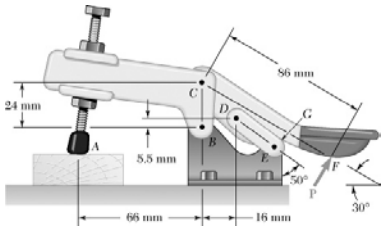
FBD joint C:



By symmetry: $F_{CD} = 255.98$ N

$$\swarrow \Sigma F_{x''} = 0: P - 2(255.98\text{ N})\sin 5.711° = 0$$

P = 50.9 N ◢ 30.0° ◀

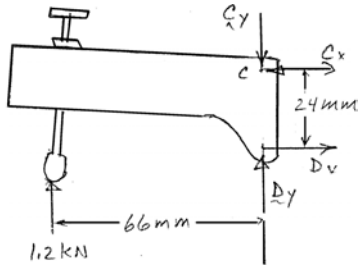


PROBLEM 6.144

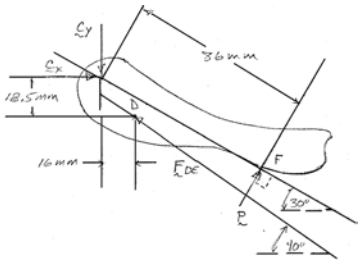
In the locked position shown, the toggle clamp exerts at *A* a vertical 1.2-kN force on the wooden block, and handle *CF* rests against the stop at *G*. Determine the force **P** required to release the clamp. (*Hint:* To release the clamp, the forces of contact at *G* must be zero.)

SOLUTION

FBD BC:



FBD CDF:



$$\circlearrowleft \Sigma M_B = 0: (24\text{ mm})C_x - (66\text{ mm})(1.2\text{ kN}) = 0$$

$$C_x = 3.3\text{ kN}$$

$$\rightarrow \Sigma F_x = 0: D_x - C_x = 0 \qquad D_x = 3.3\text{ kN}$$

$$\circlearrowleft \Sigma M_C = 0: (86\text{ mm})P$$

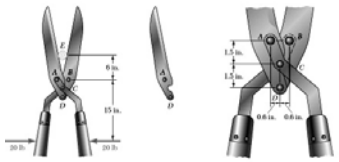
$$-\left[18.5\ mm - (16\ mm)\tan 40°\right](F_{DE}\cos 40°) = 0$$

$$F_{DE} = 22.124\,P$$

$$\rightarrow \Sigma F_x = 0: C_x - F_{DE}\cos 40° + P\sin 30° = 0$$

$$3.3\text{ kN} - (22.124\,P)\cos 40° + P\sin 30° = 0$$

$$\mathbf{P} = 201\text{ N} \angle 60° \blacktriangleleft$$



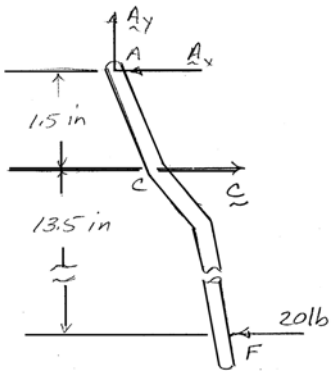
PROBLEM 6.145

The garden shears shown consist of two blades and two handles. The two handles are connected by pin *C* and the two blades are connected by pin *D*. The left blade and the right handle are connected by pin *A*; the right blade and the left handle are connected by pin *B*. Determine the magnitude of the forces exerted on the small branch *E* when two 20-lb forces are applied to the handles as shown.

SOLUTION

Note: By symmetry the vertical components of pin forces **C** and **D** are zero.

FBD handle ACF: (not to scale)

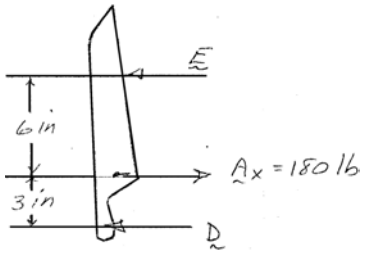


$$\uparrow \Sigma F_y = 0: A_y = 0$$

$$\circlearrowleft \Sigma M_C = 0: (13.5 \text{ in.})(20 \text{ lb}) - (1.5 \text{ in.})A_x = 0 \qquad A_x = 180 \text{ lb}$$

$$\rightarrow \Sigma F_x = 0: C - A_x - 20 \text{ lb} = 0 \qquad C = (180 + 20) \text{ lb} = 200 \text{ lb}$$

FBD blade DE:



$$\circlearrowleft \Sigma M_D = 0: (9 \text{ in.})E - (3 \text{ in.})(180 \text{ lb}) = 0$$

$$E = 60.0 \text{ lb} \blacktriangleleft$$