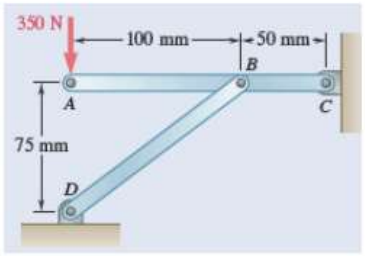
Suggested Problems: Frames and Mechanisms



PROBLEM 6.75

Determine the force in member *BD* and the components of the reaction at *C*.

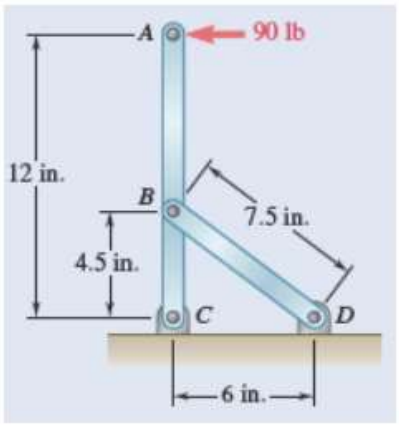
Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$F_{BD} = 1750\ \text{N}\quad C$ ◀

$\mathbf{C}_x = 1400\ \text{N} \leftarrow$ ◀

$\mathbf{C}_y = 700\ \text{N} \downarrow$ ◀



PROBLEM 6.76

Determine the force in member BD and the components of the reaction at C.

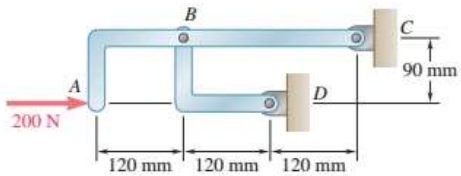
$F_{BD} = 300$ lb T ◀

$\mathbf{C}_y = 180.0$ lb ↑ ◀

$\mathbf{C}_x = 150.0$ lb ← ◀

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.



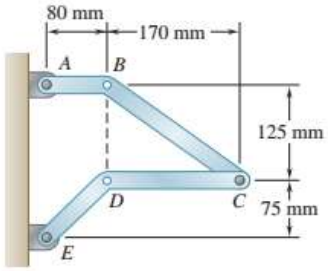
PROBLEM 6.77

For the frame and loading shown, determine the force acting on member ABC (a) at B, (b) at C.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$$\mathbf{F}_{BD} = 125.0\ \text{N}\ \nearrow \quad \mathbf{C}_x = 100\ \text{N} \leftarrow \quad \mathbf{C}_y = \frac{3}{5}(125\ \text{N}) = 75\ \text{N} \downarrow$$



PROBLEM 6.85

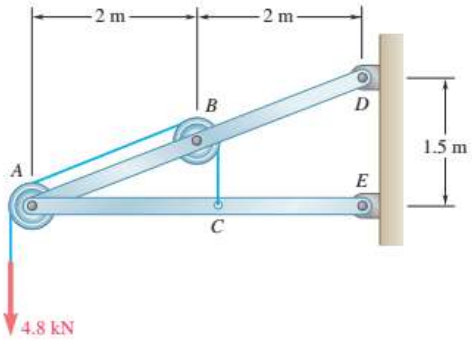
Determine the components of the reactions at A and E if a 750-N force directed vertically downward is applied (a) at B, (b) at D.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$$\mathbf{A}_x = 300\ \text{N} \leftarrow,\ \mathbf{A}_y = 660\ \text{N} \uparrow \blacktriangleleft \qquad \mathbf{A}_x = 300\ \text{N} \leftarrow,\ \mathbf{A}_y = 150.0\ \text{N} \uparrow \blacktriangleleft$$

$$\mathbf{E}_x = 300\ \text{N} \rightarrow, \mathbf{E}_y = 90.0\ \text{N} \uparrow \blacktriangleleft \qquad \mathbf{E}_x = 300\ \text{N} \rightarrow,\ \mathbf{E}_y = 600\ \text{N} \uparrow \blacktriangleleft$$



PROBLEM 6.91

Knowing that each pulley has a radius of 250 mm, determine the components of the reactions at *D* and *E*.

Steps:

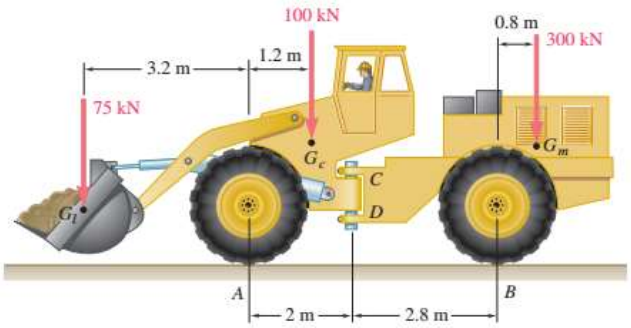
1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$\mathbf{D}_x = 13.60\ \text{kN} \rightarrow$ ◀ $\quad \mathbf{E}_y = 2.70\ \text{kN} \downarrow$ ◀

$\mathbf{E}_x = 13.60\ \text{kN} \leftarrow$ ◀ $\quad \mathbf{D}_y = 7.50\ \text{kN} \uparrow$ ◀

PROBLEM 6.97

The cab and motor units of the front-end loader shown are connected by a vertical pin located 2 m behind the cab wheels. The distance from C to D is 1 m. The center of gravity of the 300-kN motor unit is located at G_m, while the centers of gravity of the 100-kN cab and 75-kN load are located, respectively, at G_c and G_l. Knowing that the machine is at rest with its brakes released, determine (a) the reactions at each of the four wheels, (b) the forces exerted on the motor unit at C and D.



Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

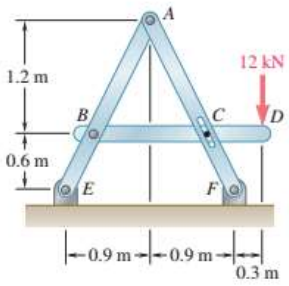
$\mathbf{B} = 162.5\ \text{kN}\uparrow$

$\mathbf{C} = 170.0\ \text{kN}\leftarrow$

$\mathbf{D}_x = 170.0\ \text{kN}\rightarrow$

$\mathbf{A} = 75.0\ \text{kN}\uparrow$

$\mathbf{D}_y = 25.0\ \text{kN}\downarrow$



PROBLEM 6.101

For the frame and loading shown, determine the components of all forces acting on member *ABE*.

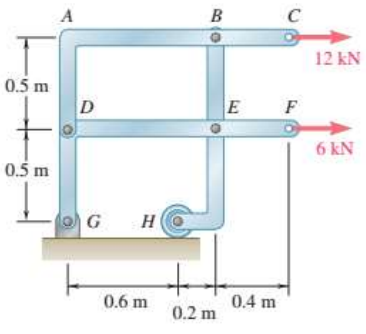
Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$\mathbf{E}_x = 23.0\ \text{kN} \leftarrow$

$\mathbf{B}_x = 36.0\ \text{kN} \rightarrow$ $\quad \mathbf{A}_x = 36.0\ \text{kN} \leftarrow$

$\mathbf{E}_y = 2.00\ \text{kN} \downarrow$ $\quad \mathbf{B}_y = 6.00\ \text{kN} \uparrow$ $\quad \mathbf{A}_y = 4.00\ \text{kN} \downarrow$



PROBLEM 6.105

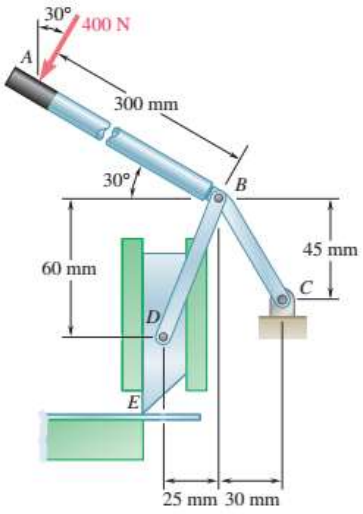
For the frame and loading shown, determine the components of the forces acting on member *DABC* at *B* and *D*.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$\mathbf{B}_x = 10.00\ \text{kN} \rightarrow$ $\mathbf{B}_y = 13.75\ \text{kN} \uparrow$ $\mathbf{D}_x = 22.0\ \text{kN} \leftarrow$

$\mathbf{D}_y = 13.75\ \text{kN} \downarrow$



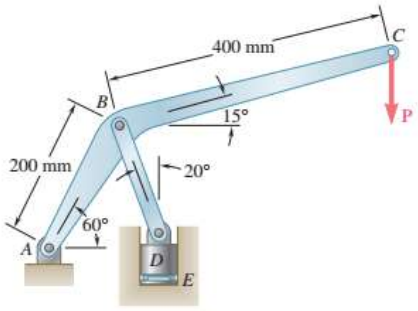
PROBLEM 6.122

The shear shown is used to cut and trim electronic circuit board laminates. For the position shown, determine (*a*) the vertical component of the force exerted on the shearing blade at *D*, (*b*) the reaction at *C*.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$(\mathbf{F}_{BD})_y = 2860\ \text{N}\downarrow$ ◀ $\mathbf{C} = 2700\ \text{N} \angle 68.5°$ ◀



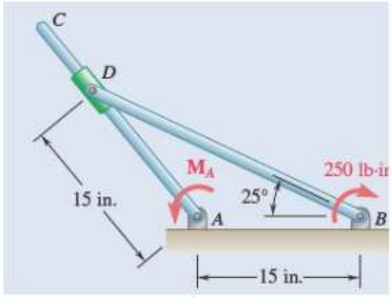
PROBLEM 6.127

The press shown is used to emboss a small seal at E. Knowing that $P = 250$ N, determine (a) the vertical component of the force exerted on the seal, (b) the reaction at A.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$\mathbf{E} = 746\ \text{N}\downarrow$ ◀ (b) $\mathbf{A} = 565\ \text{N} \angle 61.3°$ ◀



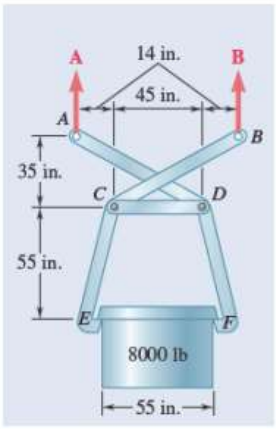
PROBLEM 6.135

Two rods are connected by a slider block as shown. Neglecting the effect of friction, determine the couple $\mathbf{M}_A$ required to hold the system in equilibrium.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$$\mathbf{M}_A = 152.2 \text{ lb·in.} \circlearrowleft$$



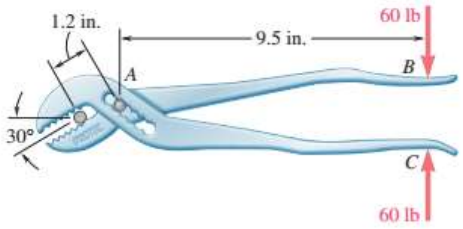
PROBLEM 6.141

A steel ingot weighing 8000 lb is lifted by a pair of tongs as shown. Determine the forces exerted at C and E on the tong BCE.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$$C = +4654.5 \text{ lb} \qquad E_x = C = 4654.5 \text{ lb} \qquad E_y = 4000 \text{ lb}$$



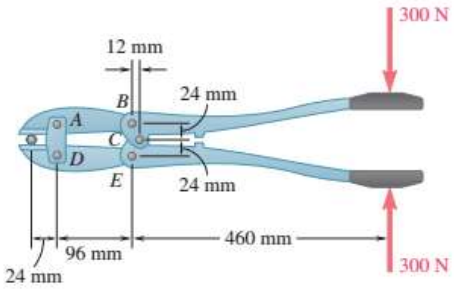
PROBLEM 6.145

The pliers shown are used to grip a 0.3-in.-diameter rod. Knowing that two 60-lb forces are applied to the handles, determine (*a*) the magnitude of the forces exerted on the rod, (*b*) the force exerted by the pin at *A* on portion *AB* of the pliers.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$Q = 475$ lb ◀ $\quad \mathbf{A}_x = 237.5$ lb ← $\quad \mathbf{A}_y = 471.4$ lb ↑



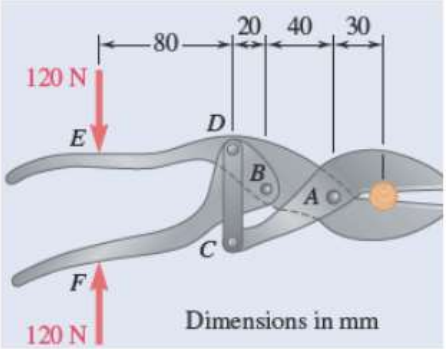
PROBLEM 6.147

In using the bolt cutter shown, a worker applies two 300-N forces to the handles. Determine the magnitude of the forces exerted by the cutter on the bolt.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$F = 44{,}800\ \text{N}$



PROBLEM 6.148

The upper blade and lower handle of the compound-lever shears are pin connected to the main element *ABE* at *A* and *B*, respectively, and to the short link *CD* at *C* and *D*, respectively. Determine the forces exerted on a twig when two 120-N forces are applied to the handles.

Steps:

1. FBD of the entire thing.
2. Write equilibrium equations (may be solvable, but likely you have too many unknowns).
3. Identify 2 force members.
4. Separately Draw fbd of each member (you don't have to draw the fbd of two force members). Make sure that the direction of each force is coherent between each fbd.
5. Write equilibrium equations for each FBD.
6. Solve for unknowns.

$Q = 1200\ \text{N} \blacktriangleleft$