4-7
Frames

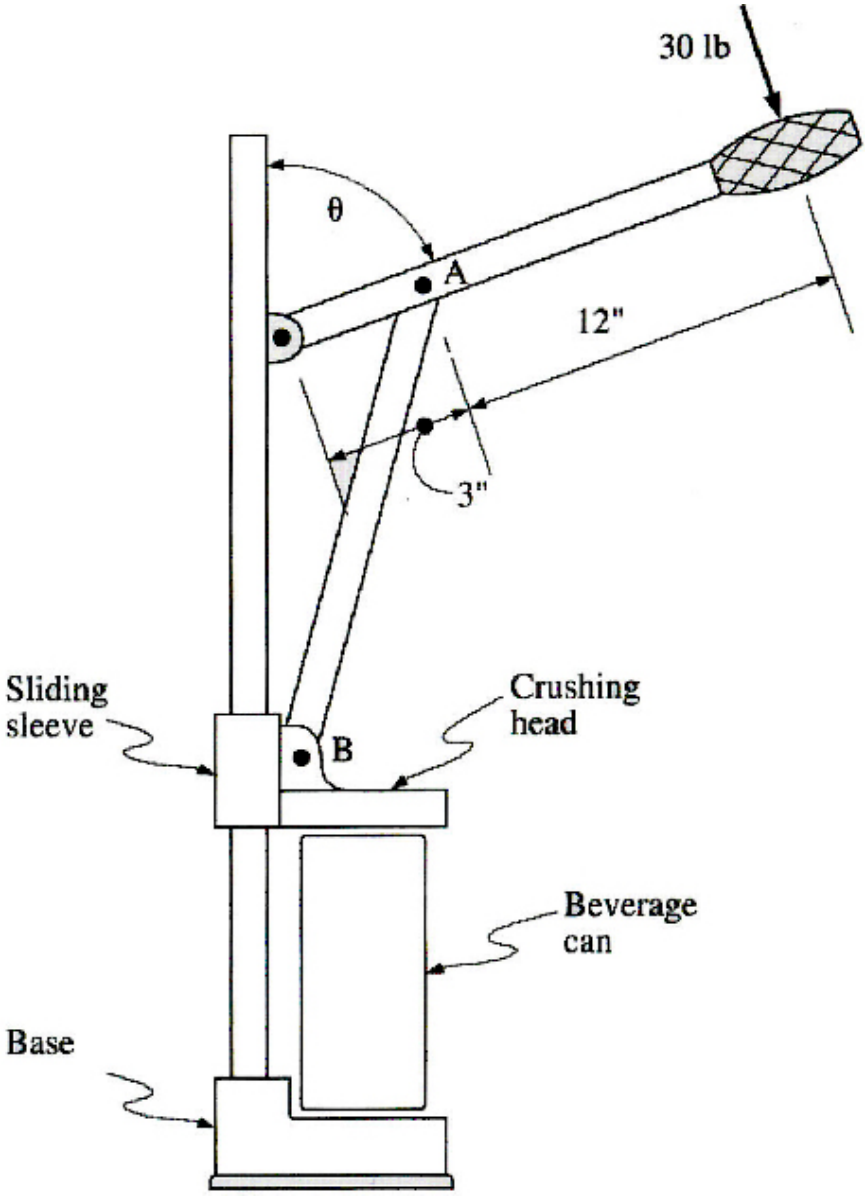
Frame
A pin-connected frame differs from a truss in that the members may no longer be connected at their ends and the loads may be applied at any point to the structure.

At least one of the members must be acted on by three or more forces. Thus the forces at the joints that hold the frame together must have x and y components.

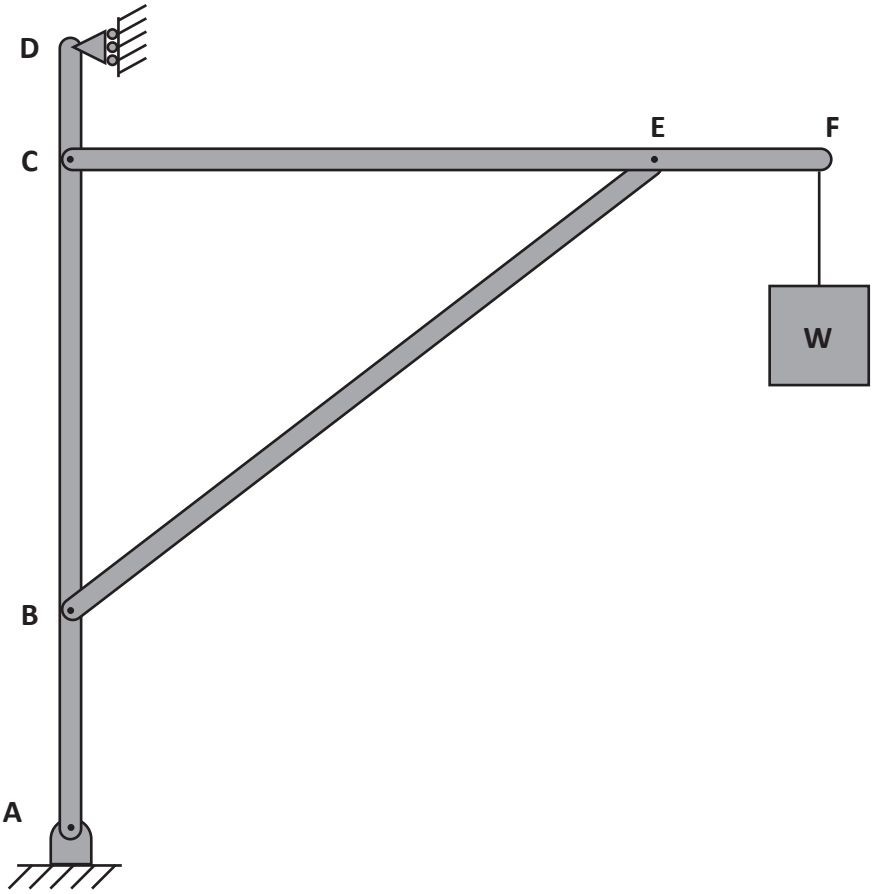
Machine
A machine differs from a pin-connected frame in that it is designed to transmit and transform input forces into output forces rather than support loads.

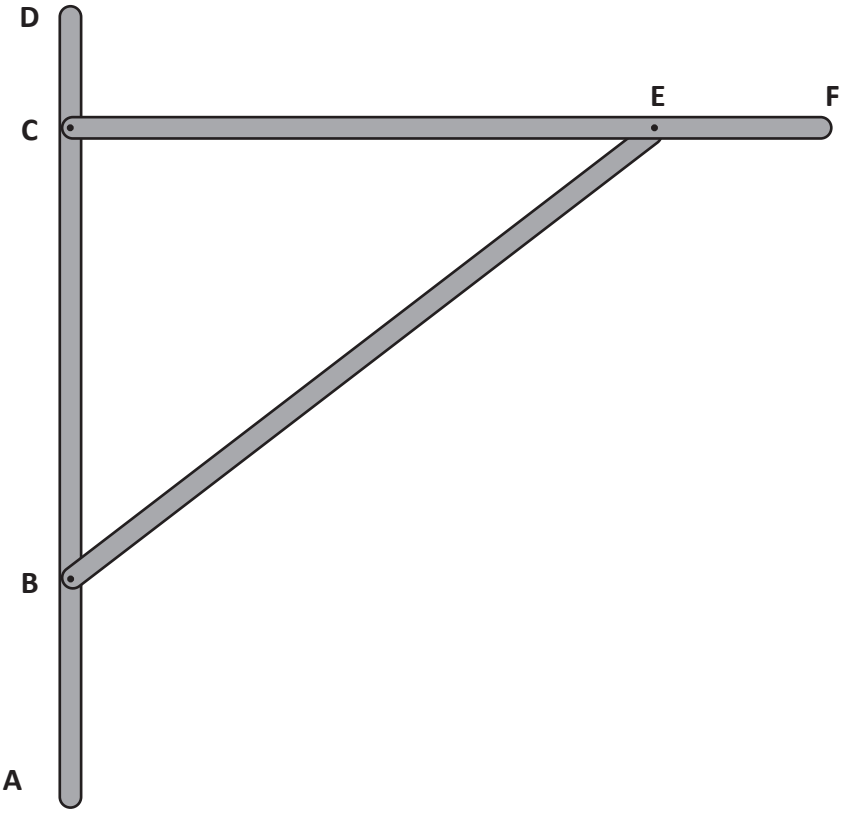
Frames are rigid structures while machines are nonrigid structures.

In machines, we will be concerned with the relationship between input and output forces necessary for equilibrium.



Frame



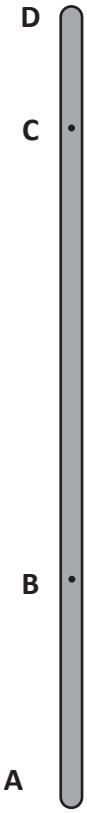


Members

Reactions

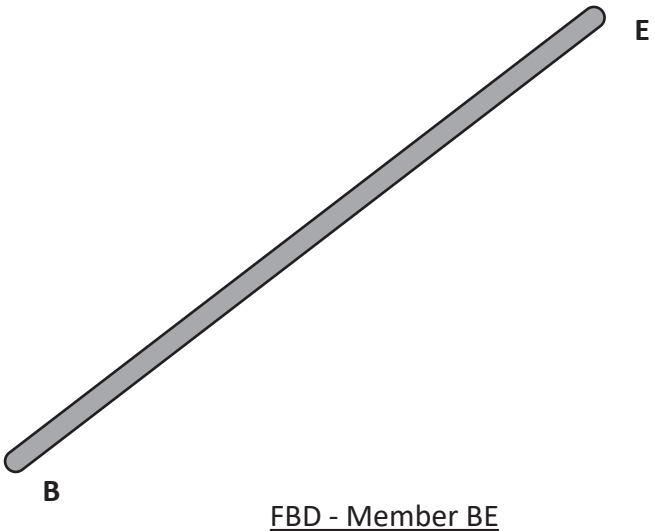
External Load

FBD - Entire Frame



FBD - Member ABCD

FBD - Member CEF



FBD - Member BE

Free Body Diagrams for the three members of the frame

Newton's Third Law – action and reaction
Must be observed when forces are drawn on the FBD's of the connected members.

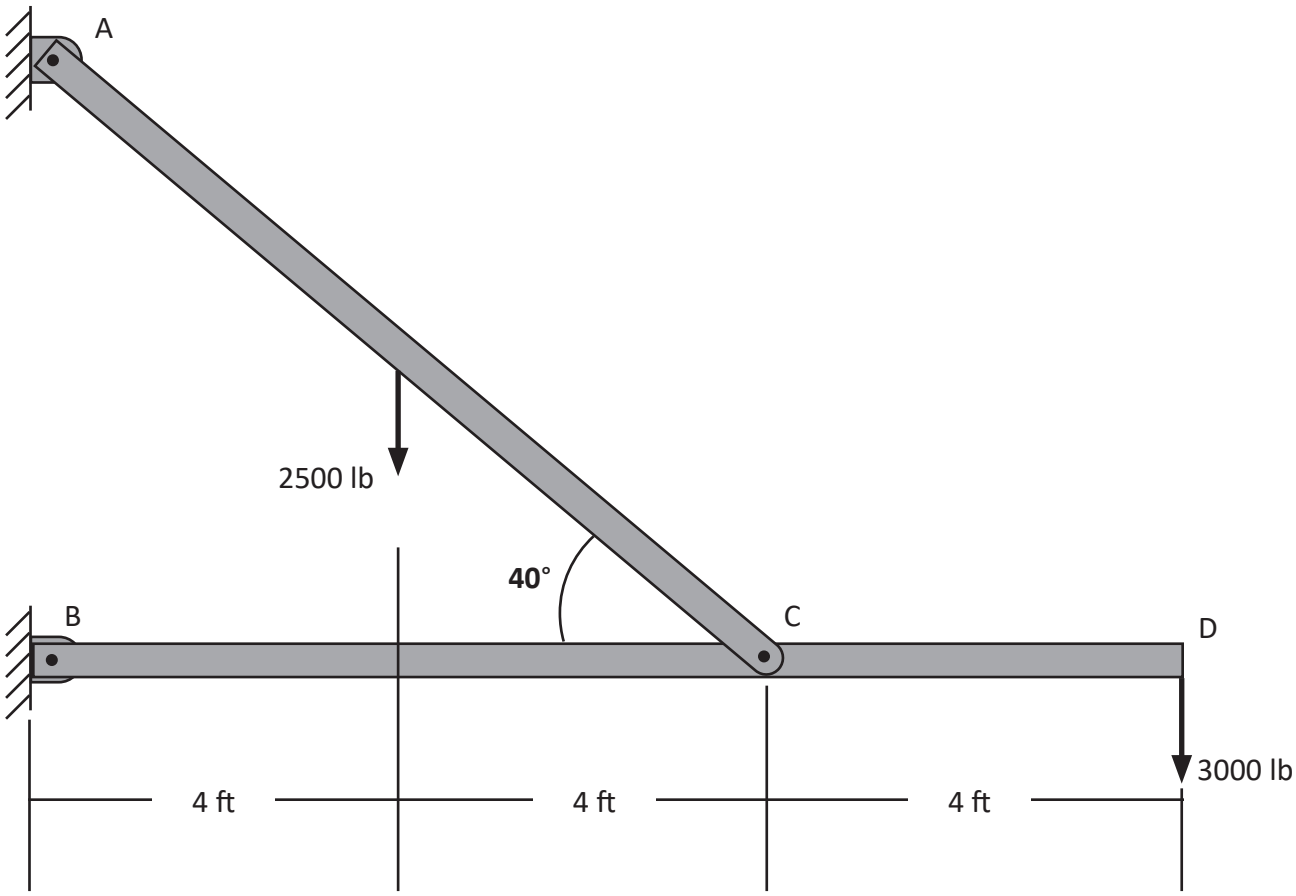
Member BE is a Two-Forec Member (TFM) and the force in the member acts along the member.

How do you check you correctly drew the forces on each FBD?

If the three free-body diagrams for the parts of the frame are combined, the forces at B, C, and E cancel and we have a FBD for the entire frame.

Example 1

A bracket is pin connected at points A, B, and D and is subjected to the loads shown. Calculate the pin reactions. Neglect the weights of the members.



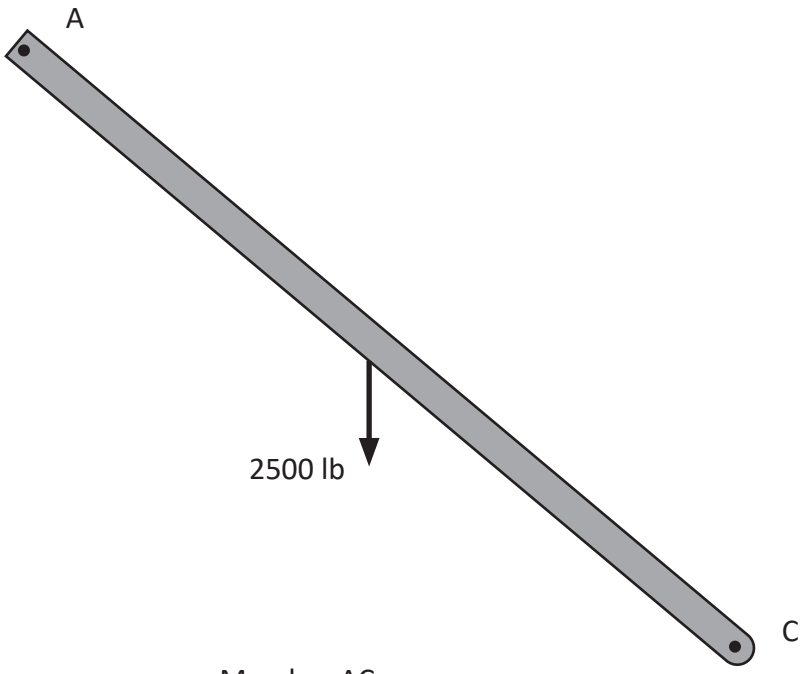
Solution.

Member BCD

FBD - Member BCD

Equilibrium Equations

Summarize the Results

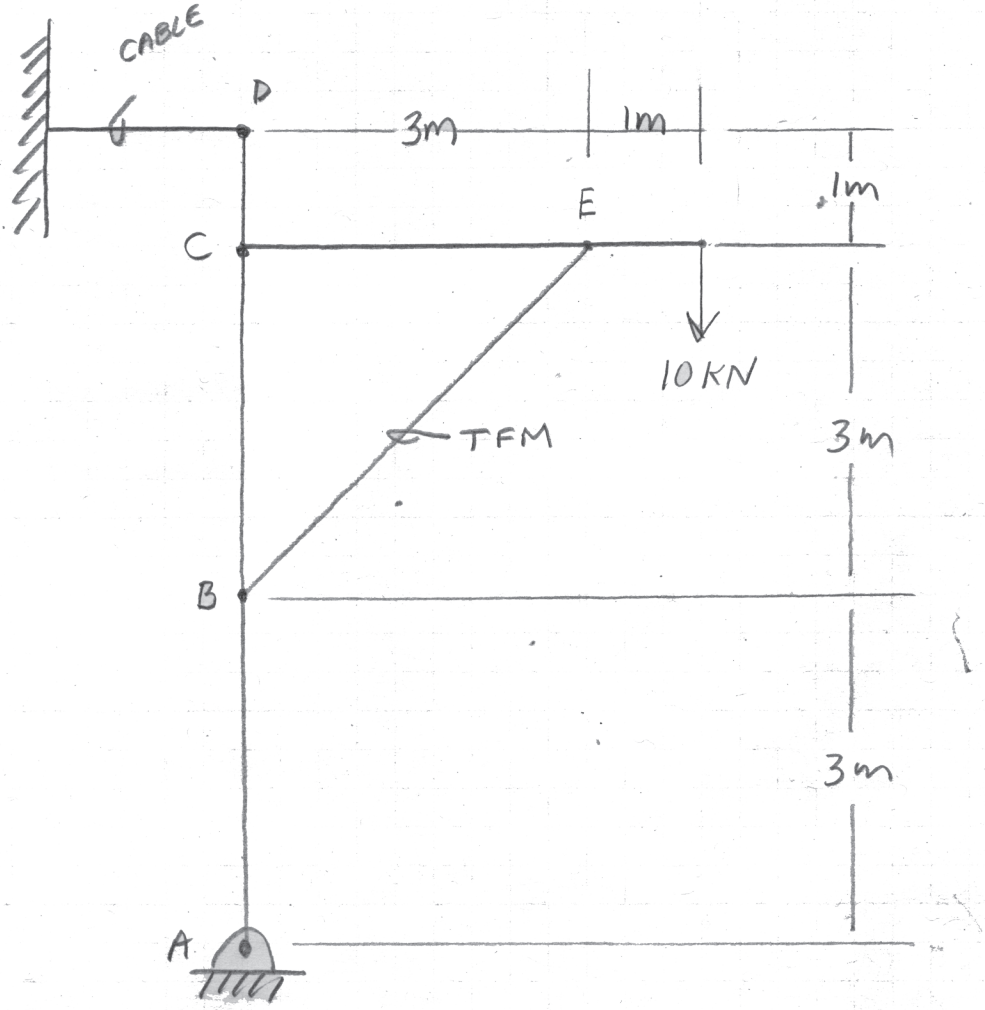


Member AC

Member BCD

Example 2. (solution #1)

Determine the pin reactions for the frame shown.



Solution.

MULTI-FORCE MEMBERS

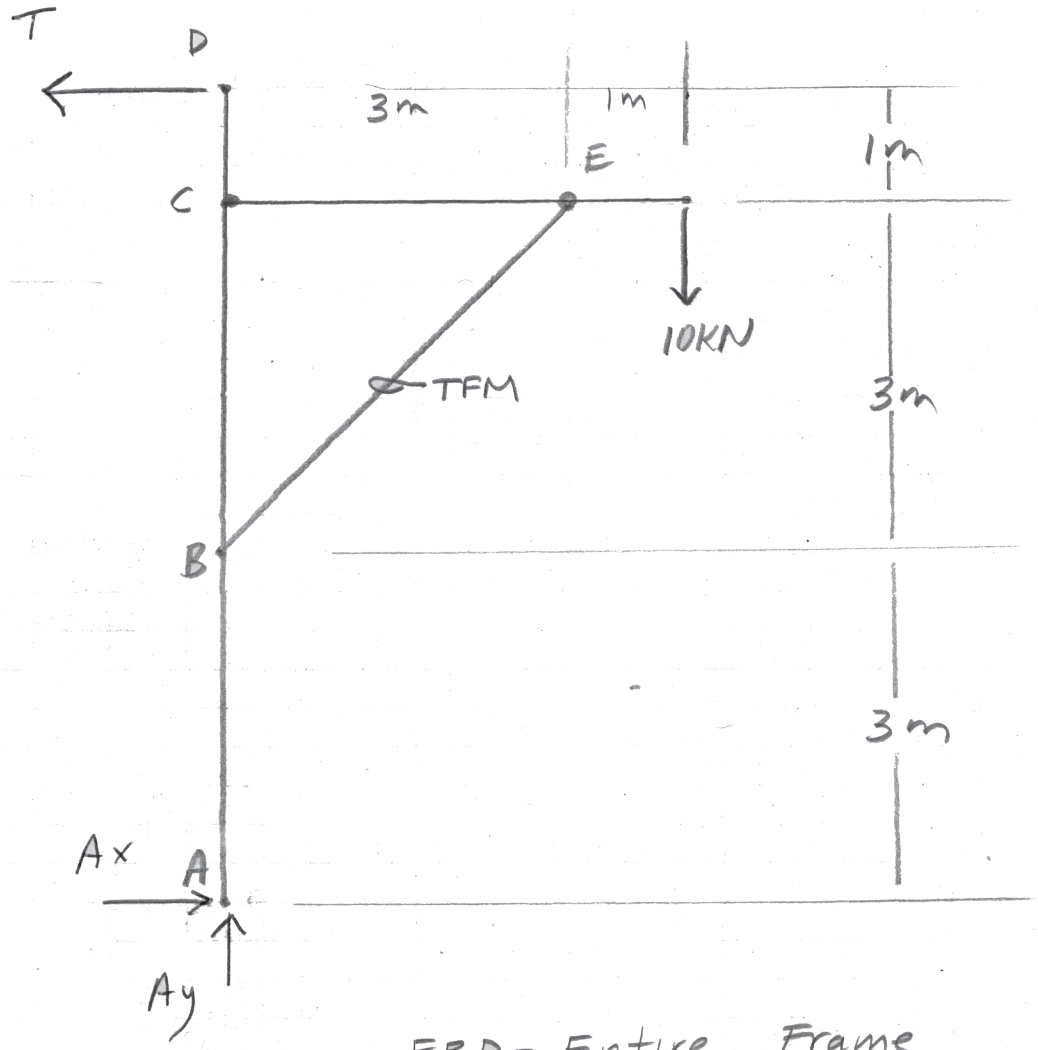
ABCD

CE

TFM

BE

Step 1. Use the FBD of the Entire Frame to solve for the support reactions.



FBD - Entire Frame

Equilibrium Equations

ccw +M ↺
cw -M ↻

$[\Sigma M_A = 0]$ $T(7m) - 10kN(4m) = 0$

$T = \frac{40\ kN \cdot m}{7m}$

$T = 5.71\ kN \leftarrow$

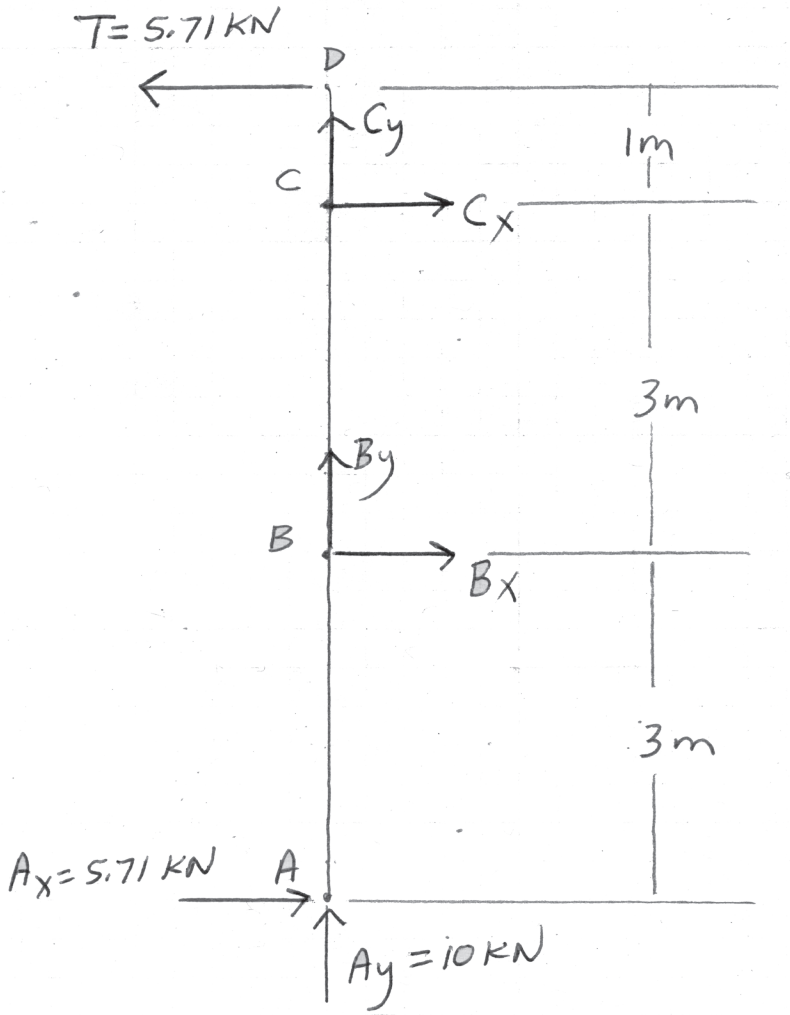
$[\Sigma F_x = 0]$ $Ax - T = 0$

$Ax = 5.71\ kN \rightarrow$

$[\Sigma F_y = 0]$ $A_y - 10\,KN = 0$

$A_y = 10\,KN \uparrow$

Member ABCD



FBD- member ABCD

Equilibrium Equations

$[\Sigma M_B = 0]$ $5.71\,KN(4m) + 5.71KN(3m) - C_x(3m) = 0$

$C_x = \frac{39.97\,KN \cdot m}{3m} = 13.3\,KN \rightarrow$

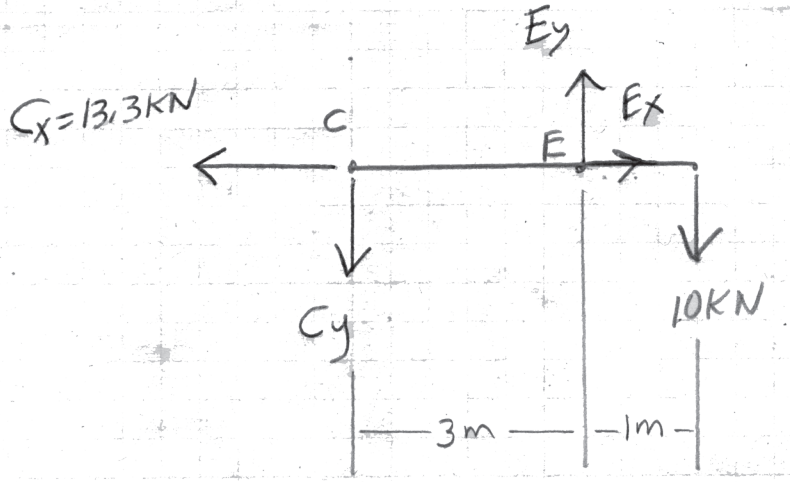
$[\Sigma F_x = 0]$ $5.71\,KN - 5.71\,KN + C_x + B_x = 0$

$B_x = -13.3\,KN \rightarrow$

or $B_x = 13.3\,KN \leftarrow$

$[\Sigma F_y = 0]$ $C_y + B_y + 10KN = 0$ (EQN 1) (C.S.4)

Member CE



FBD - member CE

Equilibrium Equations

$[\Sigma M_c = 0]$ $E_y(3m) - 10KN(4m) = 0$

$E_y = 13,3\ KN \uparrow$

$[\Sigma F_x = 0]$ $-13,3\ KN + E_x = 0$

$E_x = 13,3\ KN \rightarrow$

$[\Sigma F_y = 0]$ $-C_y + E_y - 10KN = 0$

$C_y = 13,3KN - 10KN$

$C_y = 3,3\ KN \downarrow$

From (EQN.1)

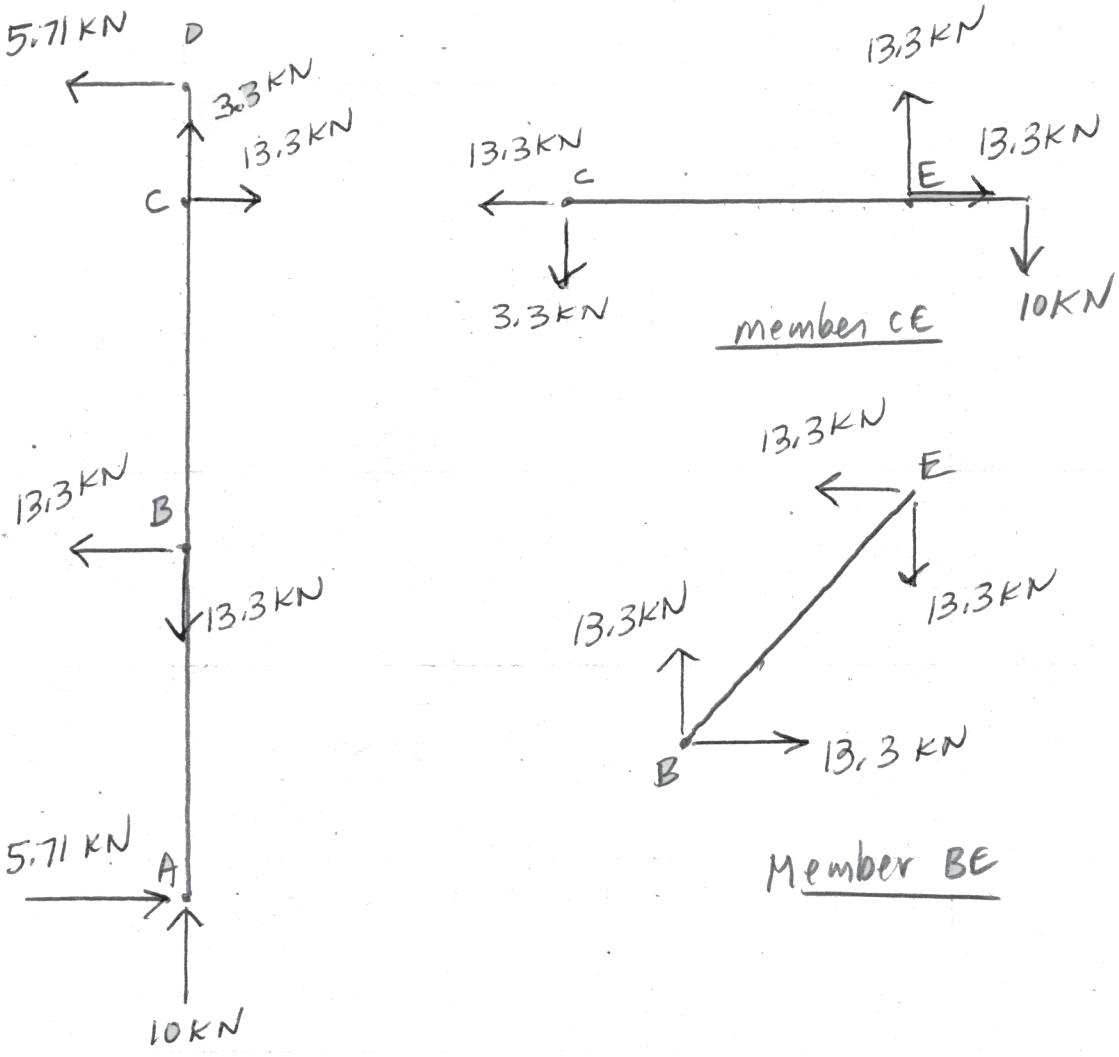
$$Cy + By + 10\,KN = 0$$

$$By = -3.3\,KN - 10\,KN$$

$$By = -13.3\,KN \uparrow$$

or $\boxed{By = 13.3\,KN \downarrow}$

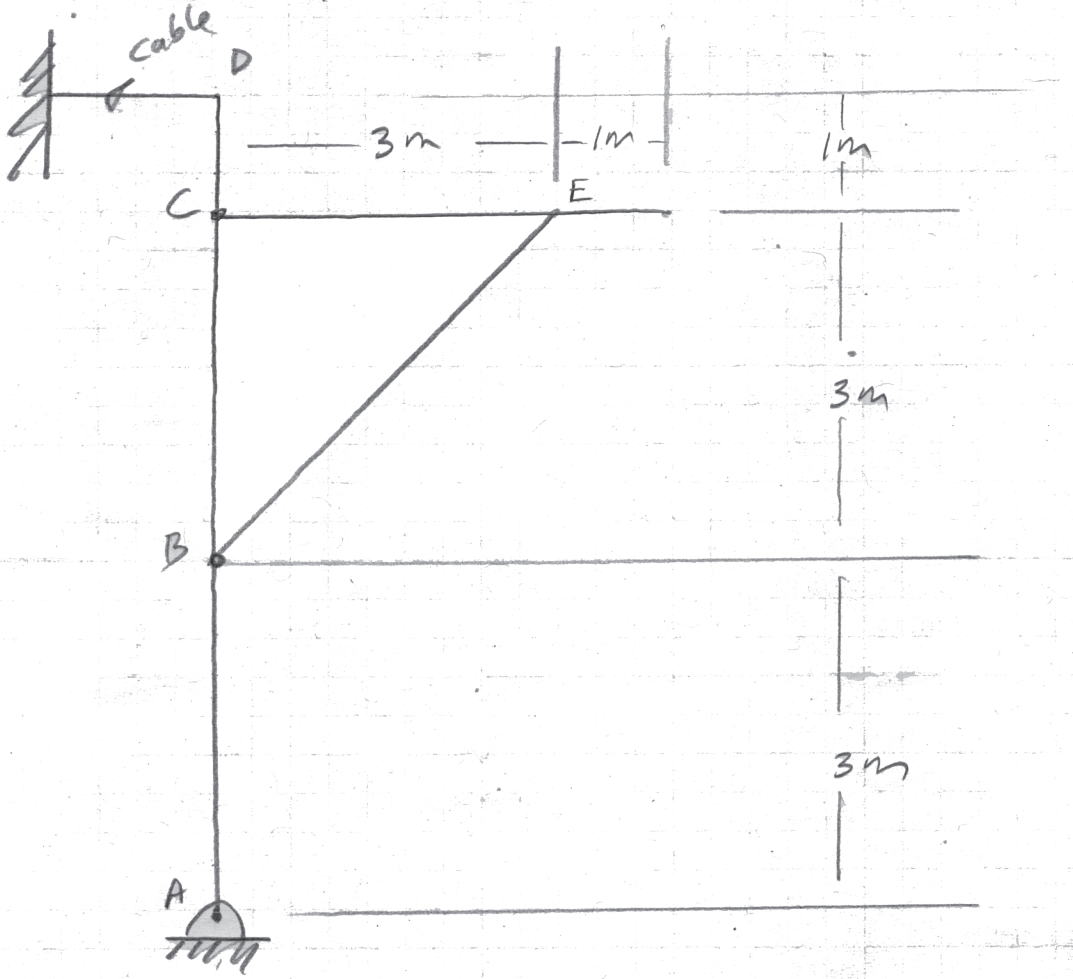
Summarize Results (NO DIMENSIONS shown)



ALL Members are in Equilibrium!

Example 2. (Solution #2)

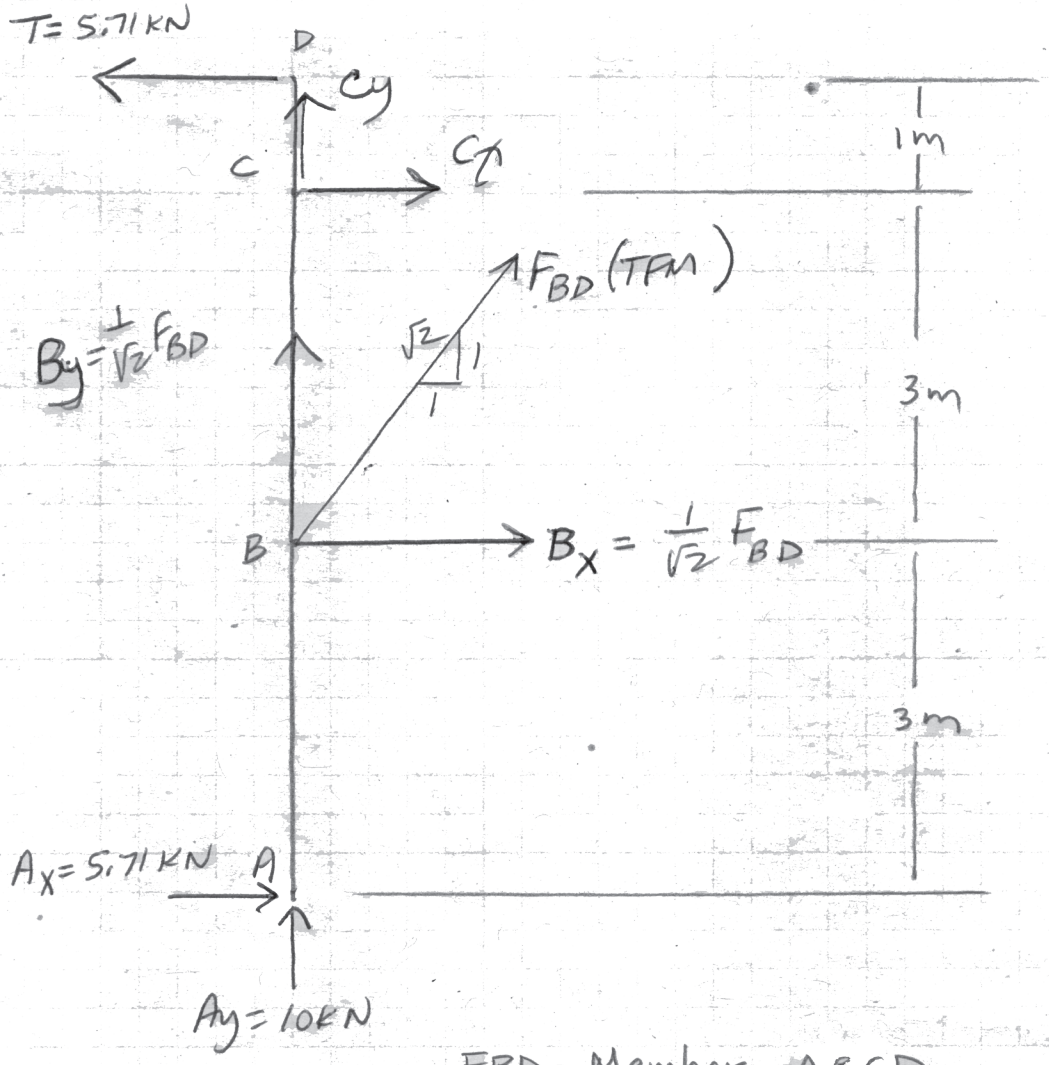
Determine the pin reactions for the frame shown.



Solution.

See Solution #1 to solve for the reactions at supports A and D.

Member ABCD



FBD - Member ABCD

Equilibrium Equations

$[\Sigma M_B = 0]$ $5.71\,kN(4m) + 5.71\,kN(3m) - C_x(3m) = 0$

$C_x = 13.3\,kN \rightarrow$

$[\Sigma F_x = 0]$ $-5.71\,kN + 5.71\,kN + C_x + \frac{1}{\sqrt{2}} F_{BD} = 0$

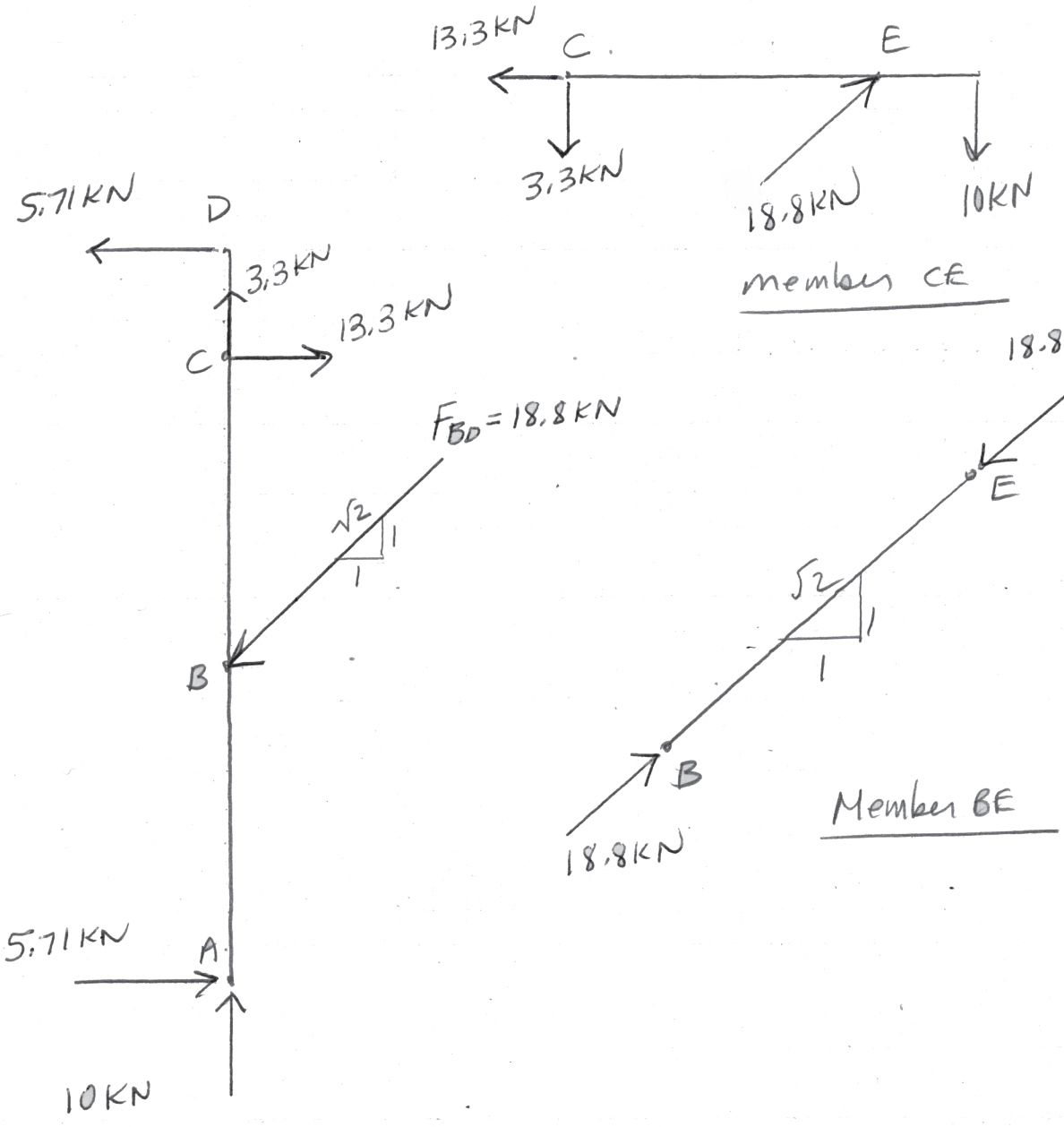
$F_{BD} = -13.3\,kN(\sqrt{2}) = -18.8\,kN\,(T)$

or $\boxed{F_{BD} = 18.8\,kN\,(C)}$

$[\Sigma F_y = 0]$ $10\,kN + \frac{1}{\sqrt{2}} F_{BD} + C_y = 0$

$C_y = -10kN - \frac{1}{\sqrt{2}}(-18.8kN) = \underline{\underline{3.3\,kN \uparrow}}$

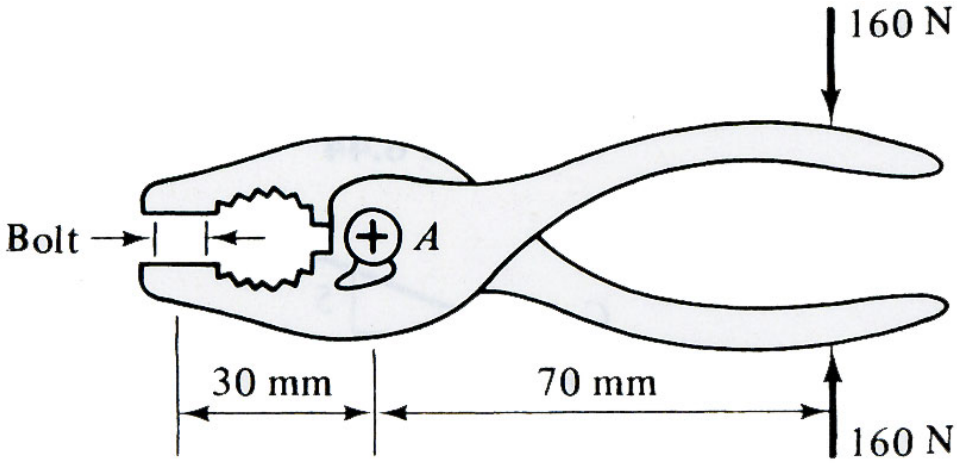
Summarize Results



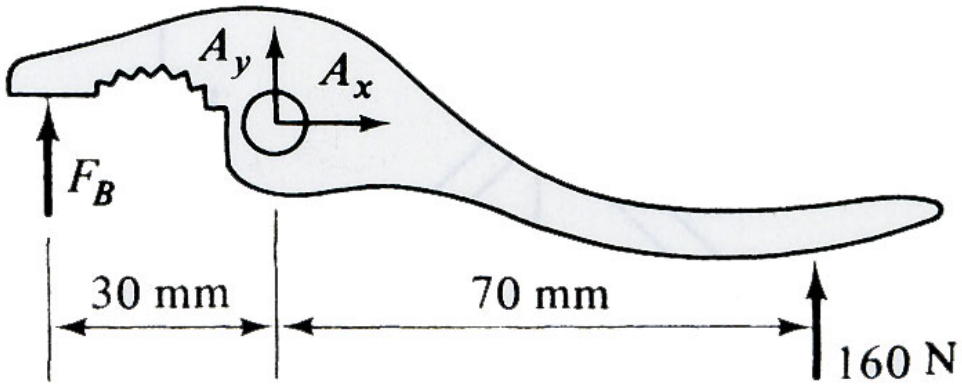
12-125 (Sol. 2)

Machines

Example 1
A force is applied to the handle of the pliers shown. Find the force applied to the bolt and the horizontal and vertical reactions at the hinge A.



Solution.

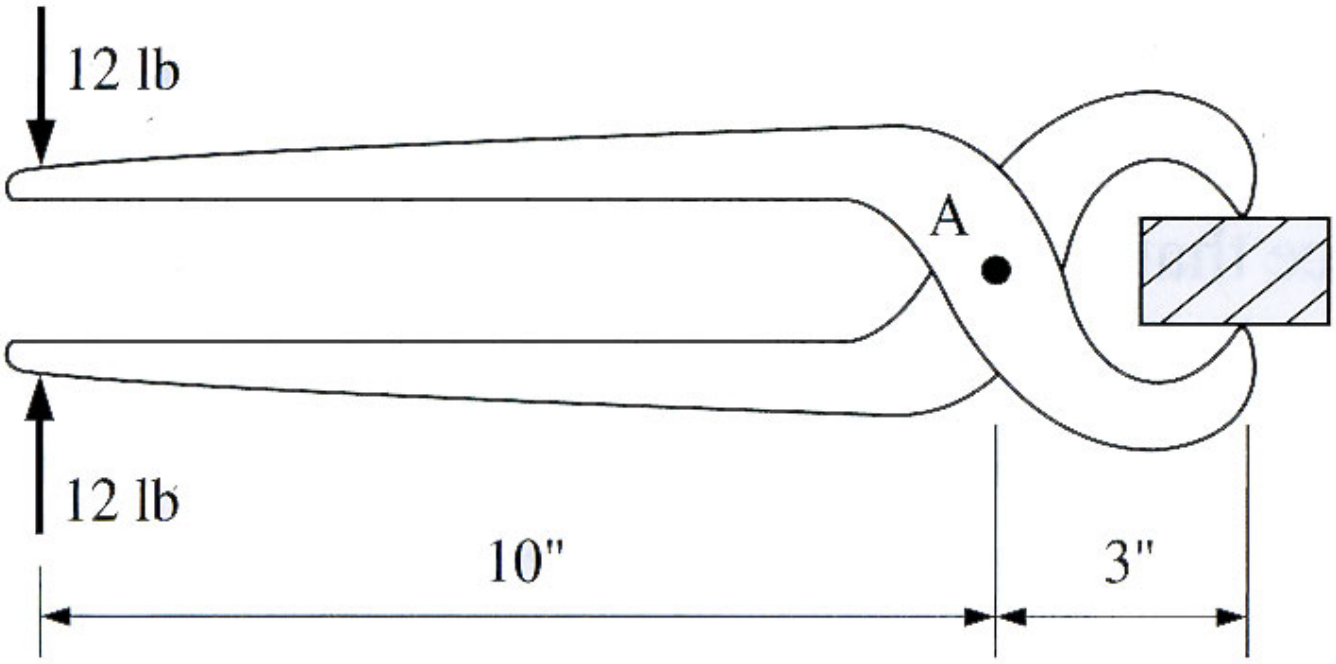


Free-Body Diagram - Upper handle of Pliers

Equilibrium Equations

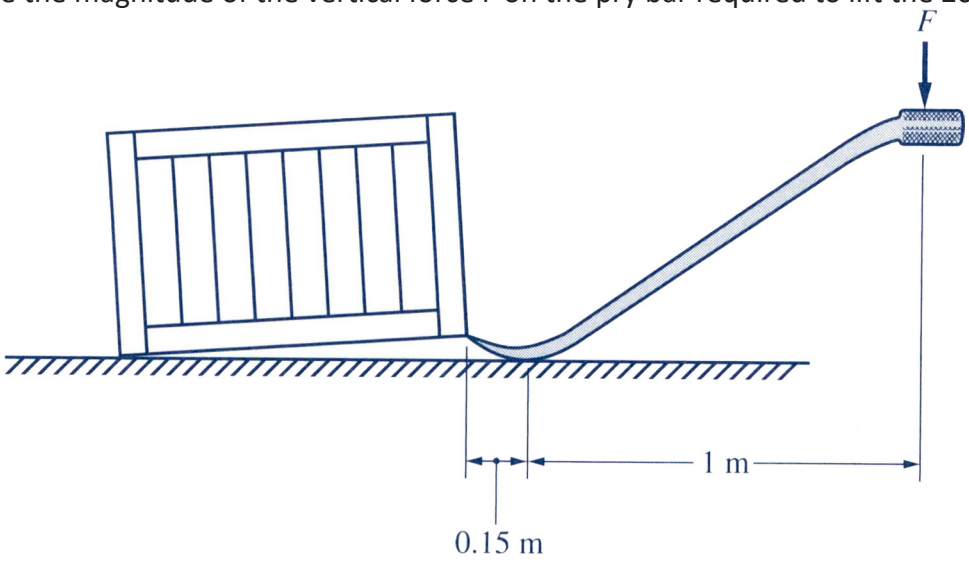
Example 2

The tongs shown are used to grip an object. For an input force of 12 lb on each handle, determine the forces exerted on the object and the forces exerted on the pin at A.

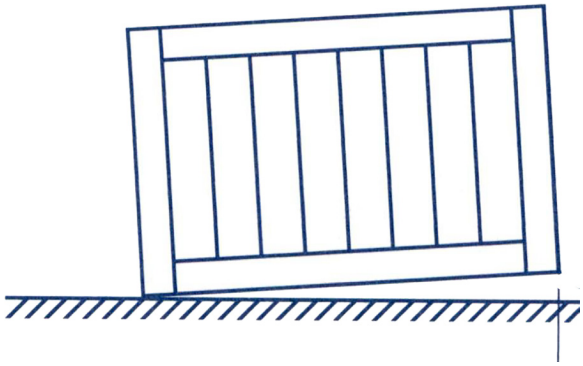


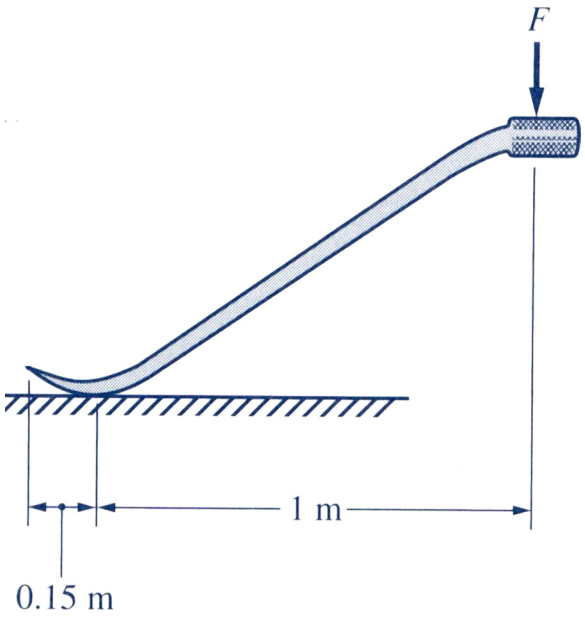
Solution.

4-39 Determine the magnitude of the vertical force F on the pry bar required to lift the 2000-kg crate.



Solution.





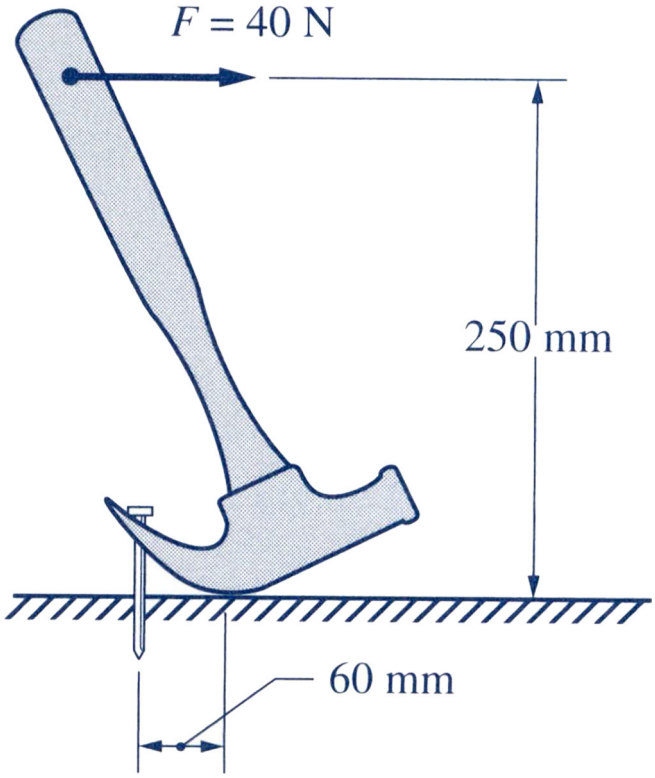
FBD - Crate

FBD - Pry Bar

Equilibrium Equations

Equilibrium Equations

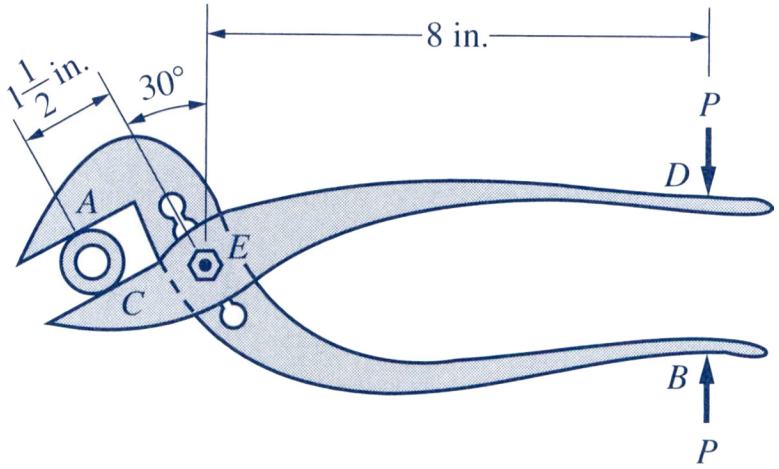
4-40 A horizontal force F of 40N is applied to the claw hammer. Determine the force exerted on the nail by the claw hammer.



Solution.

△

4-41 The pipe is held by a joint plier with a clamping force of 60 lb. Determine (a) the force P applied to the handles and (b) the force exerted by the pin E on portion AB of the plier.



Solution.