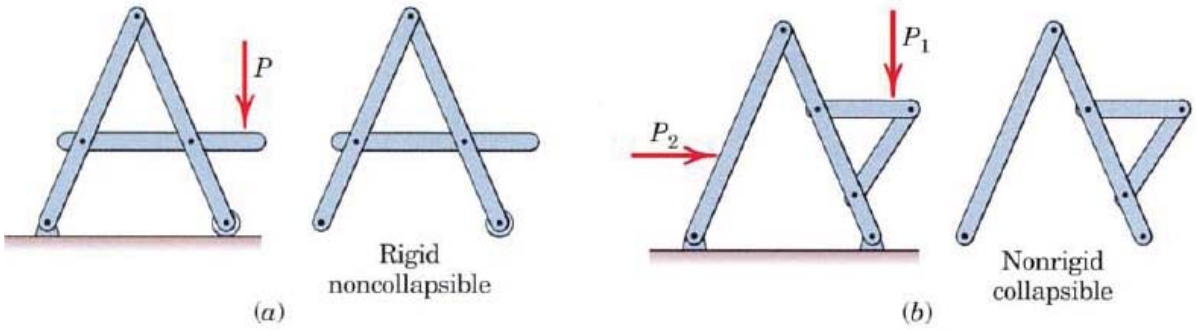
Frames and Machines

A structure is called a frame or machine if at least one of its individual members is a multiforce member. A multiforce member is defined as three or more forces acting on it.

Because frames and machines contain multiforce members, the forces in these members in general will not be in the directions of the members. Therefore, we cannot analyze these structures by the methods of joint or methods of section because these methods apply to simple trusses

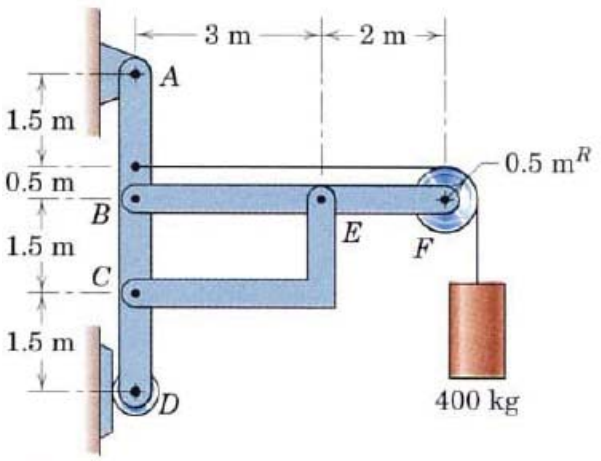


EX 19

The frame supports the 400 kg load in the manner shown. Neglect the weights of the members compared with the forces induced by the load and compute the horizontal and vertical components of all forces acting on each of the members.

Sol

from the free-body diagram of the entire frame we determine the external reactions. Thus,



$\Sigma M_A = 0$

$5.5 \times 0.4 \times 9.81 - 5 \times D = 0$

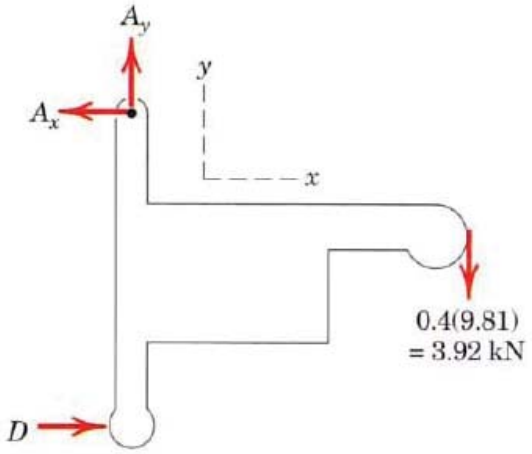
$D = 4.32$ kN

$\Sigma F_X = 0$

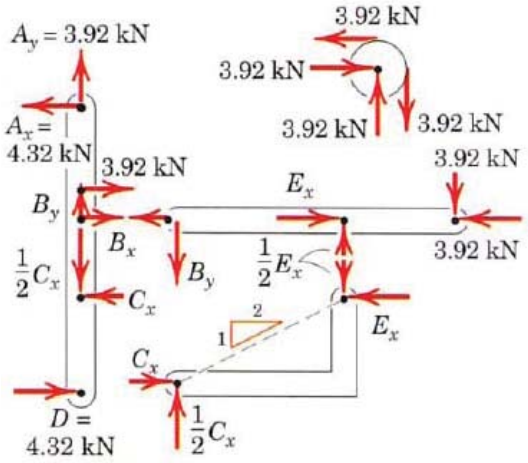
$A_x - 4.32 = 0 \Longrightarrow A_x = 4.32$

$\Sigma F_Y = 0$

$A_y - 3.92 = 0 \Longrightarrow A_y = 3.92$



To compute the horizontal and vertical components of all forces acting in each members



Member BF

$\Sigma M_B = 0$

$3.92 \times 5 - C_x \times (1/2) \times 3 = 0$

$C_x = 13.08$ kN $= E_x$

$C_y = 0.5 \times C_x = 6.54$ kN $= E_y$

$\Sigma F_X = 0$

$B_x + 3.92 - 13.08 = 0 \Longrightarrow B_x = 9.15$ kN

$\Sigma F_Y = 0$

$B_y + 3.92 - 13.0 / 2 = 0 \Longrightarrow B_y = 2.62$

For check we take member AD

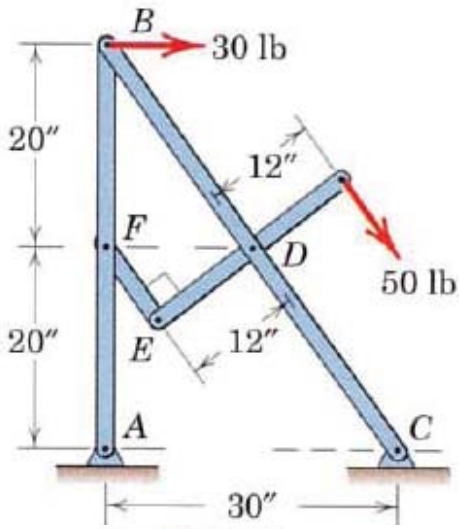
$\Sigma M_C = 0 \Longrightarrow 4.32 \times 3.5 + 4.32 \times 1.5 - 3.92 \times 2 - 9.15 \times 1.5 = 0$

$\Sigma F_X = 0 \Longrightarrow 4.32 - 13.08 + 9.15 + 3.92 + 4.32 = 0$

$\Sigma F_Y = 0 \Longrightarrow - 13.08 / 2 + 2.62 + 3.92 = 0$

EX 20

Neglect the weight of the frame and compute the forces acting on all of its members.



Sol

Free –body diagram of a whole frame.

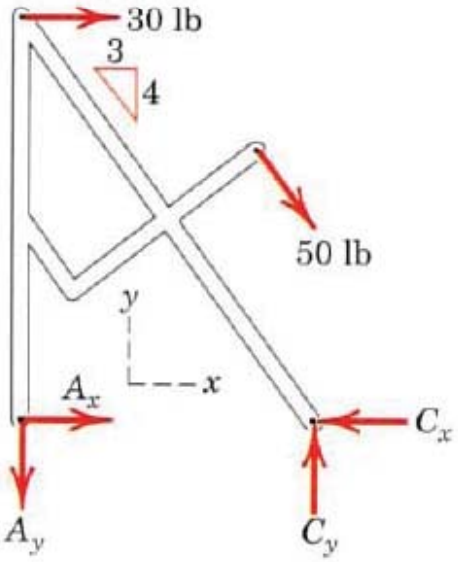
$\Sigma M_C = 0$

$50 \times 12 + 30 \times 40 - 30 \times A_y = 0$

$A_y = 60$ Ib

$\Sigma F_Y = 0$

$C_y - 50 \times (4/5) - 60 = 0 \Longrightarrow C_y = 100$ Ib



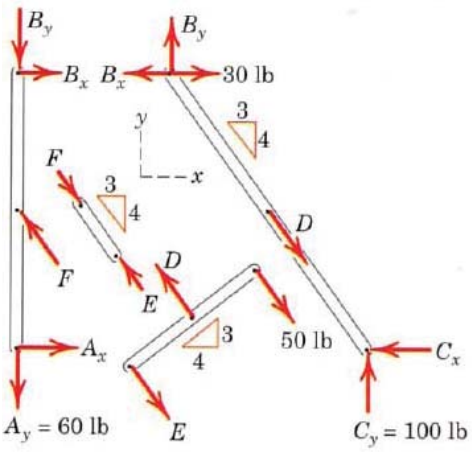
To compute the horizontal and vertical components of all forces acting in each members

Member ED.

$\Sigma M_D = 0$

$50(12) - 12E = 0 \Longrightarrow E = 50$ Ib

$\Sigma F = 0 \quad D - 50 - 50 = 0 \Longrightarrow D = 100$ Ib



Member EF.

Clearly F is equal and opposite to E with the magnitude of 5 Ib.

Member AB.

$\Sigma M_A = 0 \Longrightarrow 50\ (3/5)\ (20) - B_x\ (40) = 0 \Longrightarrow B_x = 15$ Ib

$\Sigma F_X = 0 \Longrightarrow A_x + 15 - 50\ (3/5) = 0 \Longrightarrow A_x = 15$ Ib

$\Sigma F_Y = 0 \Longrightarrow 50\ (4/5) - 60 - B_y = 0 \Longrightarrow B_y = -20$ Ib

The minus sign shows that we assigned B_y in the wrong direction.

Member BC.

$\Sigma F_X = 0 \Longrightarrow 30 + 100\ (3/5) - 15 - C_x = 0 \Longrightarrow C_x = 75$ Ib

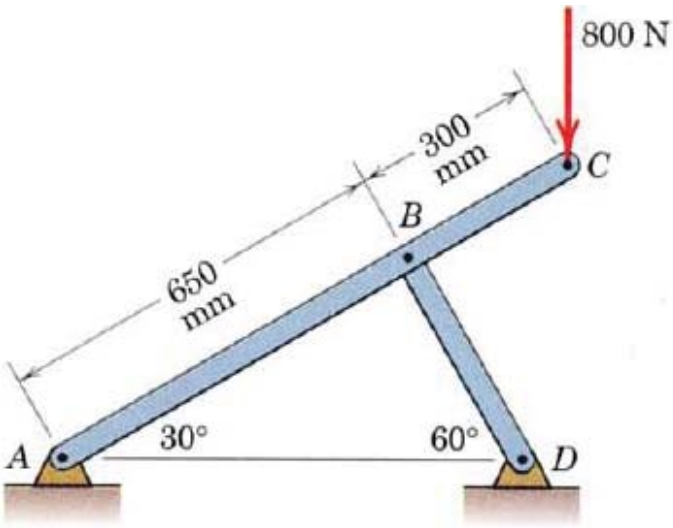
We may apply the remaining two equilibrium equations as a check. Thus,

$\Sigma F_Y = 0 \qquad 100 - 20 - 100\ (3/5) = 0$

$\Sigma M_C = 0 \qquad 20\ (30) - (\ 30 - 15\ )\ (40) = 0$

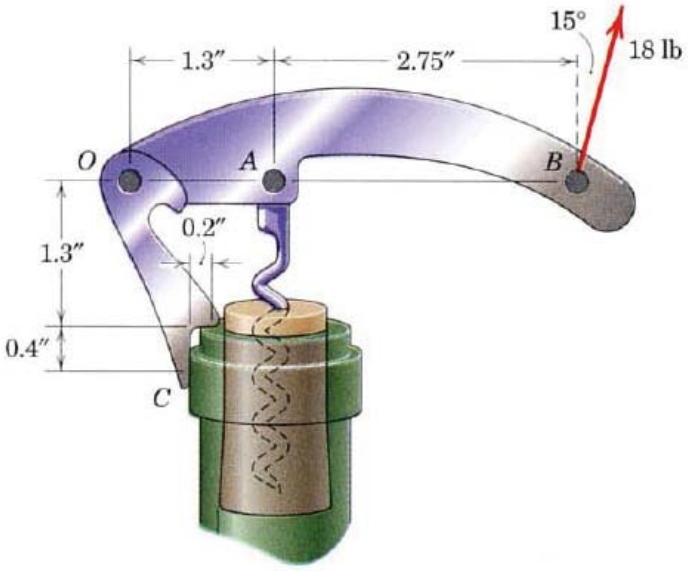
H.W

1. Determine the magnitudes of all pin reactions for the frame loaded as shown. [J. L. Merim (4-65)]



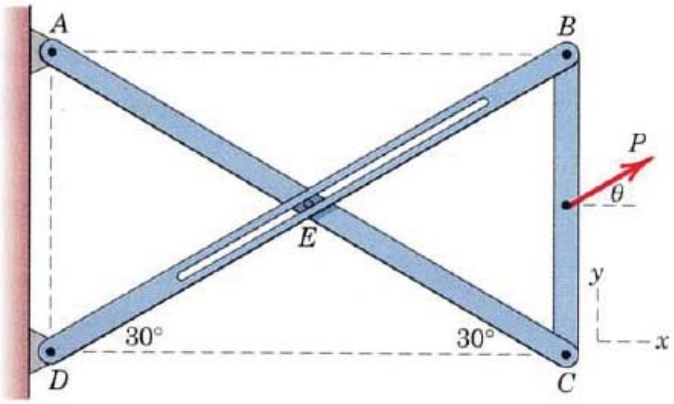
Ans. A = 512 N, B = D = 1013 N

2. An 18 Ib force is applied to the handle OAB of the cork puller. Determine the extraction force F exerted on the cork. [J. L. Merim (4-85)]



Ans. F = 54.2 Ib

3. Determine the x- and y-components of all forces acting on each member of the loaded frame for the conditions (a) $\theta = 0^{\circ}$ (b) $\theta = 30^{\circ}$. Force p is applied to the midpoint of member BC. [J. L. Merim (4-91)]



Ans.

(a)

$A_x = B_x = C_x = D_x = P/2$

$A_y = B_y = C_y = D_y = 0.289P$

$E_x = E_y = 0$

(b)

$A_x = B_x = C_x = 0.433\ P$

$A_y = C_y = 0.75P,\ B_y = 1.25P$

$D_x = 1.299P,\ D_y = 0.25P,$

$E_x = 0.866P,\ E_y = 1.5P$