Statics SKMM1203

Structural analysis: machine

Faculty of Mechanical Engineering

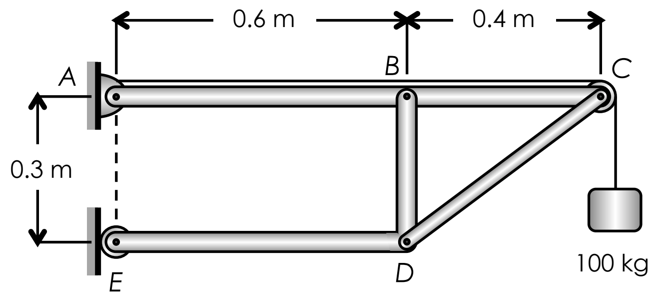
Brief concept:

Frames and machines are defined as rigid bodies comprising of at least one multi-force member. **Frames are designed for supporting loads and usually stationary, while machines are designed to modify and transmit forces. It is very important to have a correct free body diagram.**

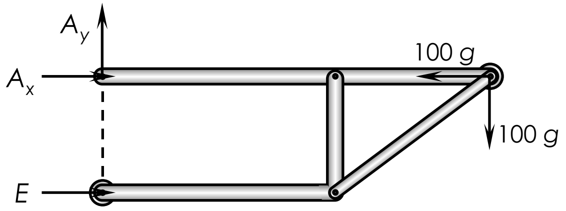
When drawing FBDs, it is useful to first identify two-force members and label of their unknowns. Doing this provides for less complicated FBDs, fewer equilibrium equations that need to be written and fewer unknowns to be determined.

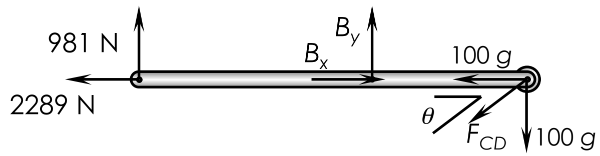
QUESTION

Determine all component of forces acting on member *ABC* of the frame shown. Pulley diameter and mass of members can be neglected.



Solution





$\theta = \tan^{-1}(0.3/0.4) = 36.87^{\circ}$

$(+\circlearrowright)\ M_A = 0$

$100g\,(1) - E\,(0.3) = 0$

$E = 3270 \text{ N} \rightarrow$

$(+\rightarrow)\ \Sigma F_x = 0$

$A_x + 3270 - 100g = 0$

$A_x = -2289 \text{ N}$

$A_x = 2289 \text{ N} \leftarrow$

$(+\uparrow)\ \Sigma F_y = 0$

$A_y - 100g = 0$

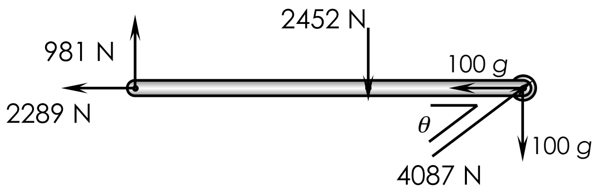
$A_y = 981 \text{ N} \uparrow$

$(+\circlearrowright)\ M_B = 0$

$100g\,(0.4) + F_{CD} \sin\theta\,(0.4) + 981(0.6) = 0$

$392.4 + 0.24\,F_{CD} + 588.6 = 0$

$F_{CD} = -4087.5 \text{ N} \qquad \therefore\ F_{CD} = 4087.5 \text{ N} \nearrow$



$(+\rightarrow)\ \Sigma F_x = 0$

$-2289 + B_x - (-4087.5\cos\theta) - 100g = 0$

$-2289 + B_x + 3270 - 100g = 0$

$B_x = 0 \text{ N}$

$(+\uparrow)\ \Sigma F_y = 0$

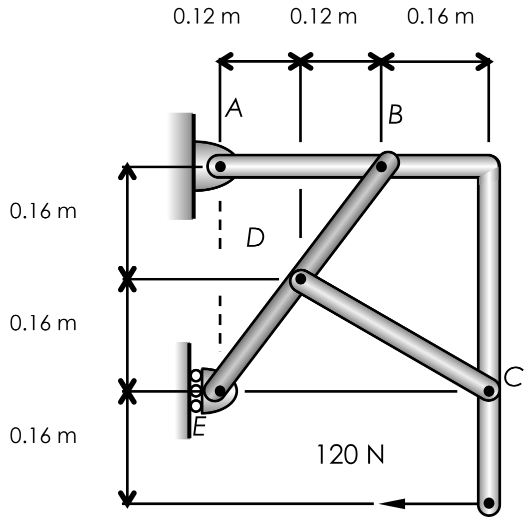
$981 + B_y - (-4087.5\sin\theta) - 100g = 0$

$981 + B_y + 2452.5 - 100g = 0$

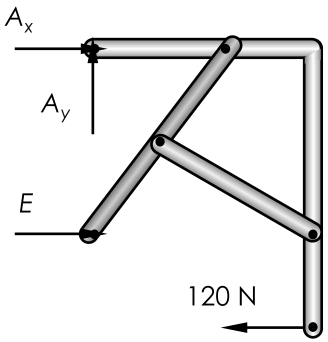
$B_y = -2452.5 \text{ N} \qquad \therefore\ B_y = 2452.5 \text{ N} \downarrow$

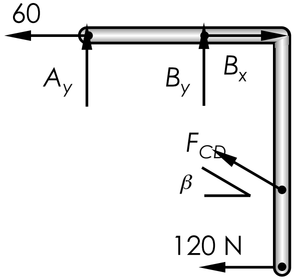
QUESTION

Determine all components of forces acting on member *ABC*.



Solution





$(+\circlearrowright) M_A = 0$

$120(0.48) - E(0.32) = 0$

$E = 180 \text{ N} \quad (\rightarrow)$

$(+\circlearrowright) M_E = 0$

$120(0.16) + A_x(0.32) = 0$

$A_x = -60 \text{ N} \quad (\leftarrow)$

$(+\uparrow) \Sigma F_y = 0$

$A_y = 0 \text{ N}$

$(+\circlearrowright) M_B = 0$

$120(0.48) - F_{CD} \sin 29.7^\circ)(0.16) + F_{CD} \cos 29.7^\circ)(0.32) = 0$

$57.6 - 0.0793 F_{CD} + 0.278 F_{CD} = 0$

$F_{CD} = -290 \text{ N} \qquad 29.7^\circ$

$(+\uparrow) \Sigma F_y = 0$

$B_y + (-290 \sin 29.7^\circ) = 0$

$B_y = 143.7 \text{ N} \quad (\uparrow)$

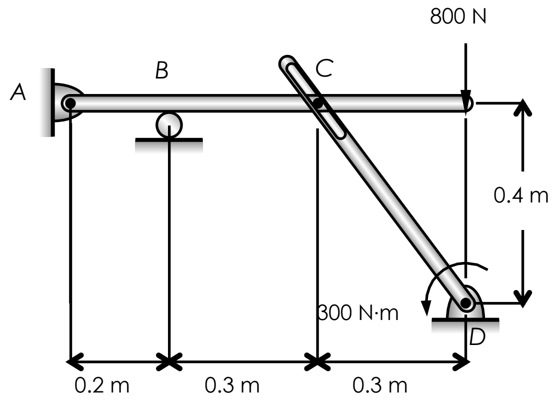
$(+\rightarrow) \Sigma F_x = 0$

$-60 - 120 - (-290 \cos 29.7^\circ) + B_x = 0$

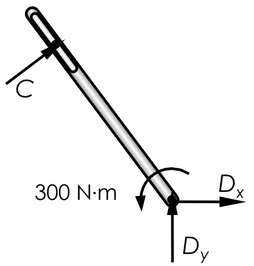
$B_x = -71.9 \text{ N} \quad (\leftarrow)$

QUESTION

Determine all components of forces acting on member *ABC*.



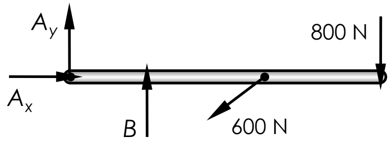
Solution



$(+\circlearrowleft) M_D = 0$

$C(0.5) - 300 = 0$

$C = 600$ N



$(+\circlearrowleft) M_A = 0$

$800(0.8) + 600(3/5)(0.5) - B(0.2) = 0$

$640 + 180 - 0.2\,B = 0$

$B = 4100$ N

$(+\rightarrow) \Sigma F_x = 0$

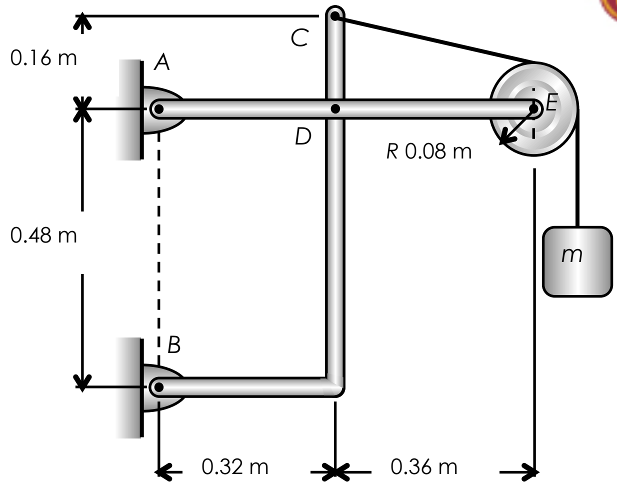
$A_x - 600(4/5) = 0$

$A_x = 480$ N $(\rightarrow)$

$(+\uparrow) \Sigma F_y = 0$

$A_y + 4100 - 360 - 800 = 0$

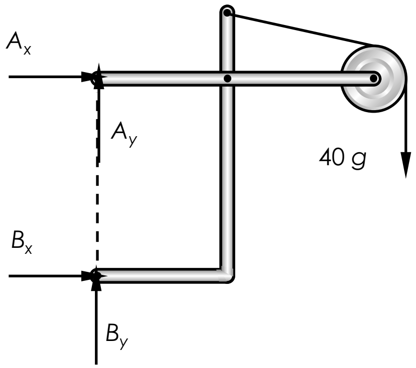
$A_y = -2940$ N $(\downarrow)$

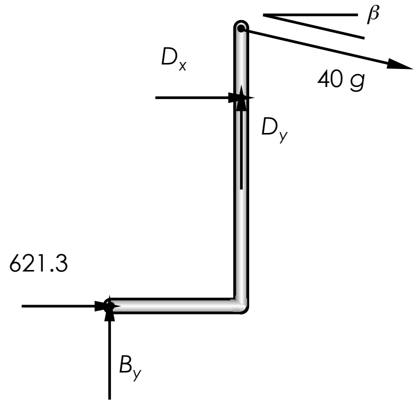


QUESTION

The mass m = 40 kg. Determine all components of forces acting on member *CDB*.

Solution





$(+\circlearrowright)\ M_A = 0$

$40\ g\ (0.76) - B_x\ (0.48) = 0$

$B_x = 621.3$ N $(\rightarrow)$

$(+\circlearrowright)\ M_D = 0$

$(40\ g \cos 12.53^\circ)(0.16) - (621.3)(0.48) + B_y\ (0.32) = 0$

$61.3 - 298.2 + 0.32\ B_y = 0$

$B_y = 740.3$ N $(\uparrow)$

$(+\rightarrow)\ \Sigma F_x = 0$

$621.3 + 40\ g \cos 12.53^\circ + D_x = 0$

$D_x = -1004$ N $(\leftarrow)$

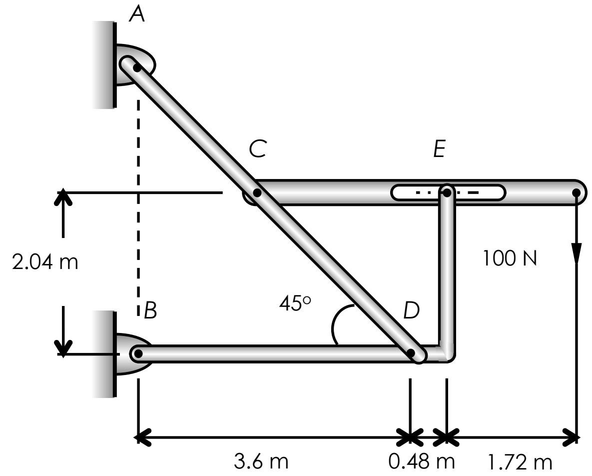
$(+\uparrow)\ \Sigma F_y = 0$

$740.3 - 40\ g \sin 12.53^\circ + D_y = 0$

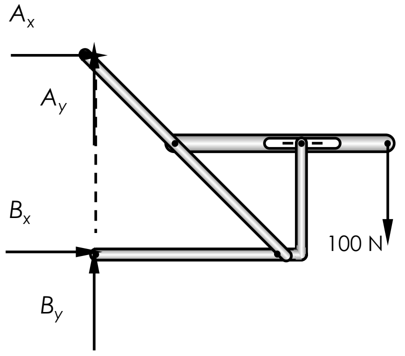
$D_y = -655.2$ N $(\downarrow)$

QUESTION

Determine all components of forces acting on member *BDE*.



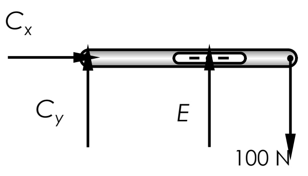
Solution



$(+\circlearrowleft) M_A = 0$

$100(5.8) - B_x(3.6) = 0$

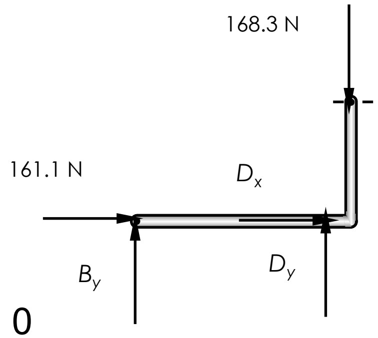
$B_x = 161.1 \text{ N} \ (\rightarrow)$



$(+\circlearrowleft) M_C = 0$

$100(4.24) - E(2.52) = 0$

$E = 168.3 \text{ N} \ (\uparrow)$



$(+\circlearrowleft) M_D = 0$

$168.3(0.48) + B_y(3.6) = 0$

$B_y = -22.4 \text{ N} \ (\downarrow)$

$(+\rightarrow) \Sigma F_x = 0$

$D_x + 161.1 = 0$

$D_x = -161.1 \text{ N} \ (\leftarrow)$

$(+\uparrow) \Sigma F_y = 0$

$-22.4 + D_y - 168.3 = 0$

$D_y = 190.7 \text{ N} \ (\uparrow)$