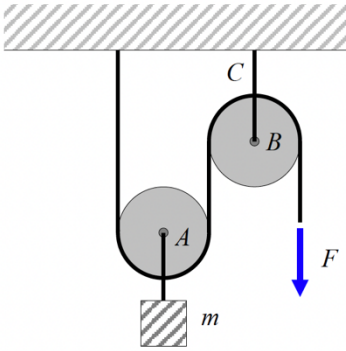
Name_____

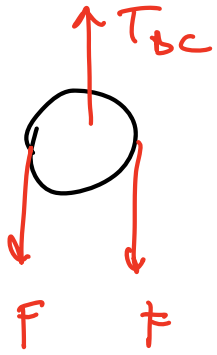
Problem 1 (15 points). The system of cables and pulleys shown below supports an object of mass m = 10 kg. Determine the following:

a) The force ***F*** necessary to keep the system in equilibrium. (*10 points*)

b) The force in cable *BC*, assuming the system is in equilibrium. (*5 points*)



FBD for pulley B



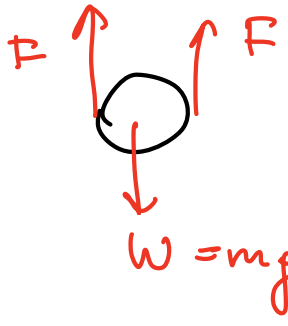
2pt

$\Sigma F_y = 0$

$T_{BC} - 2F = 0$ 2pt

$T_{BC} = 2F$ (1)

FBD for pulley A



4pt

$\Sigma F_y = 0$

$2F - W = 0$

$F = \frac{W}{2} = \frac{(10)(9.81)}{2} = 49.05\,N$ 5pt

From (1) $T_{BC} = 2F = 98.1\,N$

Part a) $F = 49.05\,N$ 1pt

Part b) $T_{BC} = 98.1\,N$ 1pt

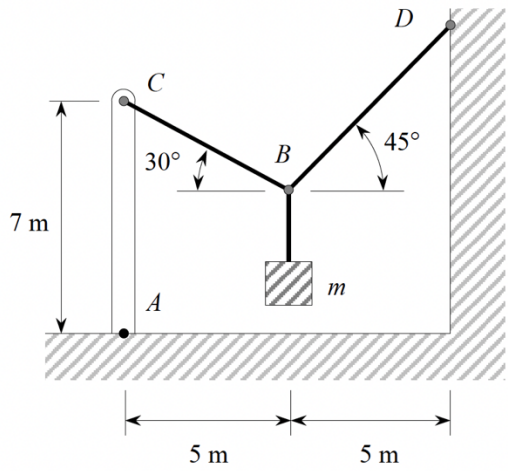
Name_____

Problem 2 (20 points). The system of cables shown below is in equilibrium and supports an object *m* with a weight of 100 N. AC is a rod that is fixed to the ground. Determine the following:

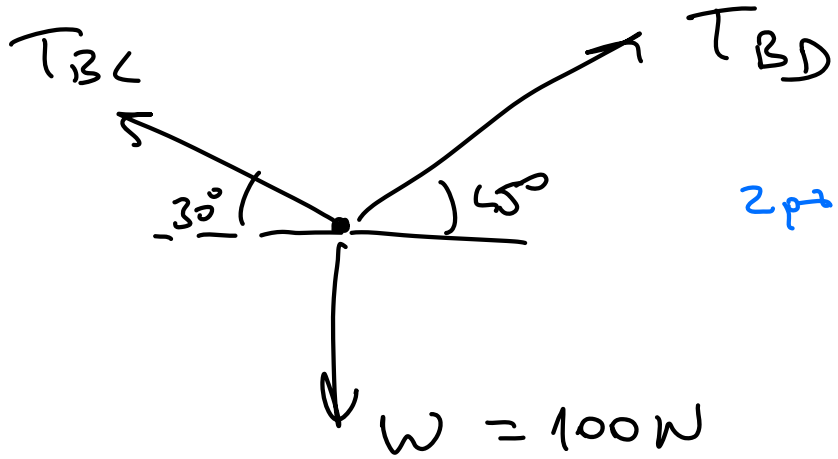
a) The magnitude of the forces in cables *BC* and *BD*. (*10 points*)

b) The moment of the force exerted by cable *BC* about point *A*. (*5 points*)

c) The moment of the forces exerted by cables *BC* and *BD* about point *B*. (*5 points*)



FBD at point B



2pt

$\Sigma F_x = 0$ $\quad T_{BD}\cos 45 - T_{BC}\cos 30 = 0$ (1) 2pt

$\Sigma F_y = 0$ $\quad T_{BD}\sin 45 + T_{BC}\sin 30 - 100 = 0$ (2) 2pt

① $T_{BD} = T_{BC}\dfrac{\cos 30}{\cos 45} = T_{BC}\left(\dfrac{0.8660}{0.70711}\right)$

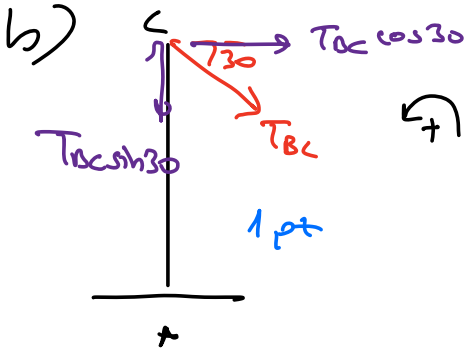
Substitute into ②

$(1.2247\,T_{BC})(0.70711) + T_{BC}(0.5) = 100$ 2pt

$T_{BC} = 73.2\ N$ 1pt

$T_{BD} = 1.2247(73.2) = 89.66\ N$ 1pt

b)



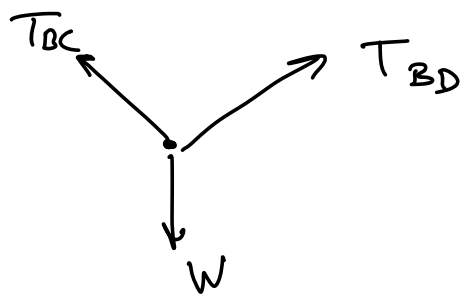
1pt

3pt

↺+ $M_A = -(T_{BC}\cos 30)(7) + T_{BC}\sin 30\,(0)$

$= -435\ Nm$ 1pt

c)

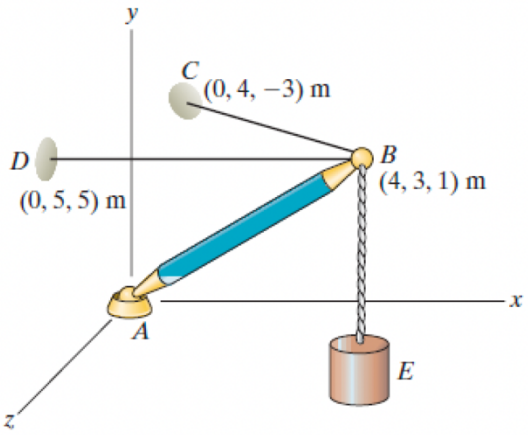


Forces are concurrent through point B their moment is zero

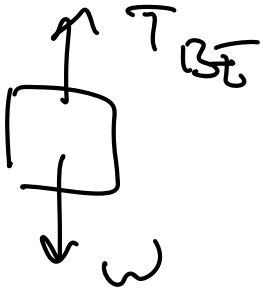
$M_B = 0$ 5pt

Name_____

Problem 3 (20 points). If the mass of the suspended object E is 75 kg, determine the moment about point A of the force that cable BD exerts on the 'ball' at point B.



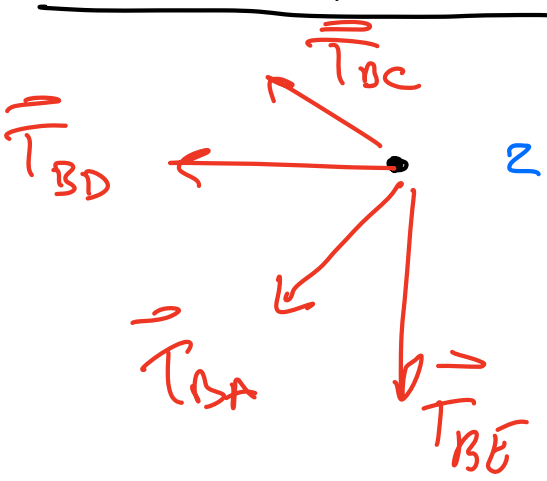
FBD of mass



$T_{BE} = W = (75)(9.81)$

$= 735.75$

FBD of point B



A(0,0,0)

B(4,3,1)

C(0 4 -3)

D(0, 5, 5)

$\vec{r}_{BA} = -4\vec{i} - 3\vec{j} - 1\vec{k}$ m $|\vec{r}_{AB}| = \sqrt{26}$ m 1

A-B

$\vec{r}_{BC} = -4\vec{i} + \vec{j} - 4\vec{k}$ m $|\vec{r}_{BC}| = \sqrt{33}$ m 1

C-B

$\vec{r}_{BD} = -4\vec{i} + 2\vec{j} + 4\vec{k}$ m $|\vec{r}_{BD}| = 6$ m 1

Name_____

$$\vec{T}_{BA} = T_{BA}(-0.784\vec{i} - 0.588\vec{j} - 0.196\vec{k})$$

$$\vec{T}_{BC} = T_{BC}(-0.696\vec{i} + 0.174\vec{j} - 0.696\vec{k})$$

$$\vec{T}_{BD} = T_{BD}(-0.667\vec{i} + 0.333\vec{j} + 0.667\vec{k})$$

$\Sigma F_x = 0$ 2

① $T_{BA}(-0.784) + T_{BC}(-0.696) + T_{BD}(-0.667) = 0$

$\Sigma F_y = 0$ 2

② $T_{BA}(-0.588) + T_{BC}(0.174) + T_{BD}(0.333) = 735.75$

$\Sigma F_z = 0$ 2

③ $T_{BA}(-0.196) + T_{BC}(-0.696) + T_{BD}(0.667) = 0$

③ − ① will cancel T_{BC}

$1.333T_{BD} + 0.588T_{BA} = 0$ $\quad T_{BA} = -2.267\,T_{BD}$

① − 4×③ will cancel T_{BA}

$2.089T_{BC} + (-3.33)T_{BD} = 0$ $\quad T_{BC} = 1.596\,T_{BD}$

Replace T_{BA} and T_B in ②

$(-2.267T_{BD})(-0.588) + (1.596T_{BD})(0.174) + T_{BD}(0.333) = 735.75N$

$1.9437\,T_{BD} = 735.75N$

$\boxed{T_{BD} = 378\ N}$ 2

$$M_{T_{BD}\ w.r.t\ A} = \vec{r}_{AB} \times \vec{T}_{BD}$$

$$\vec{r}_{AB} = 4\vec{i} + 3\vec{j} + \vec{k} \quad 2$$

$$\vec{T}_{BD} = -252.12\vec{i} + 125.8\vec{j} + 252.12\vec{k}$$

$$M = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 4 & 3 & 1 \\ -252.12 & 125.8 & 252.12 \end{vmatrix} = \vec{i}\left((3)(252.12) - 1(125.8)\right) - \vec{j}\left(4 \times 252.12 - (1)(-252.12)\right) + \vec{k}\left((4)(125.8) - (3)(-252.12)\right)$$

$$\boxed{M = 630.6\vec{i} - 1261\vec{j} + 1260\vec{k}} \quad 2$$