Department of Mechanical Engineering (NITC)

S1ME **ZZ1001D ENGINEERING MECHANICS** **Tutorial Test 4-Set2**

Time: One Hour **Answer Key** Maximum Marks: 20

1. A block having a mass of 500 kg is held by five cables as shown in Fig. 1. What are the tensions in these cables? Lower cables are identical and are identically connected at ends.

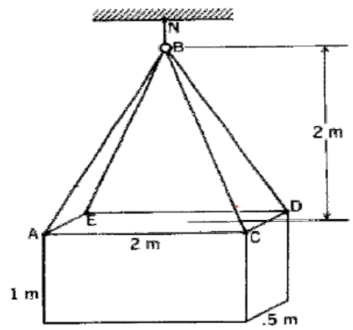


Figure 1

Solution:

2) As the lower cables are identical,

$T = T_{AB} = T_{EB} = T_{CB} = T_{DB}$

For the equilibrium of the block,

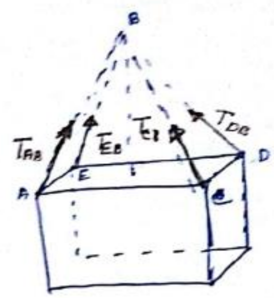
$4T\sin\theta = mg = 500\,(9.81)$

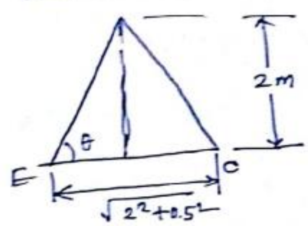
$\Rightarrow T = \dfrac{500\,(9.81)}{4\sin(62.734^\circ)} = \underline{1379.53\ N}$

$T_{BN} = 4T\sin\theta = mg$

$\Rightarrow T_{BN} = 500\,(9.81)$

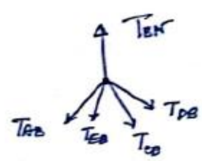
$\Rightarrow T_{BN} = \underline{4905\ N}$





$\tan\theta = \dfrac{2\times 2}{\sqrt{2^2+0.5^2}}$

$\Rightarrow \theta = 62.734^\circ$



2. **A** thin hoop of radius 1 m and weight 500 N rests on an incline (Fig. 2). What friction force *f* at *A* is needed for this configuration? What is the tension in wire *CB***?**

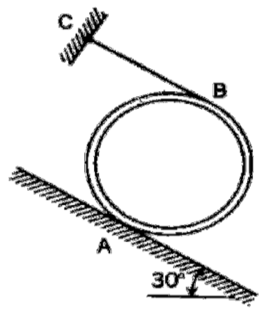


Figure 2

Solution:

$\sum M_A = 0$

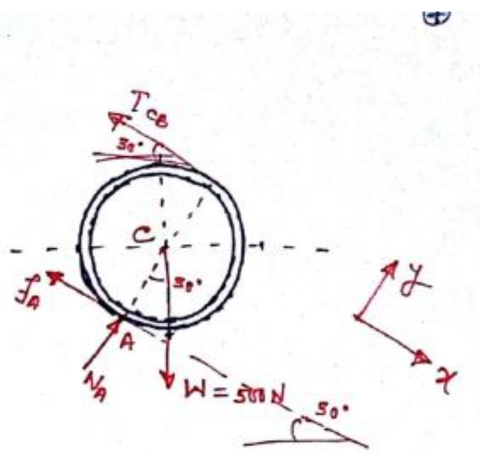
$\Rightarrow \quad 2\,T_{CB} = (1 \sin 30^\circ)\,W$

$\Rightarrow \quad T_{CB} = \frac{1}{4}(500)$

$\Rightarrow \quad T_{CB} = \underline{125\text{ N}}$ Ans

$\sum M_C = 0 \quad \Rightarrow \quad T_{CB} = f_A$

$\Rightarrow \quad f_A = \underline{125\text{ N}}$ Ans



3. Two cables *GH* and *KN* support a rod *AB* which connects to a ball-and-socket joint support at *A* and supports a 500-kg body ***C*** at *B* (Fig. 3). What are the tensions in the cable and the supporting forces at *A*?

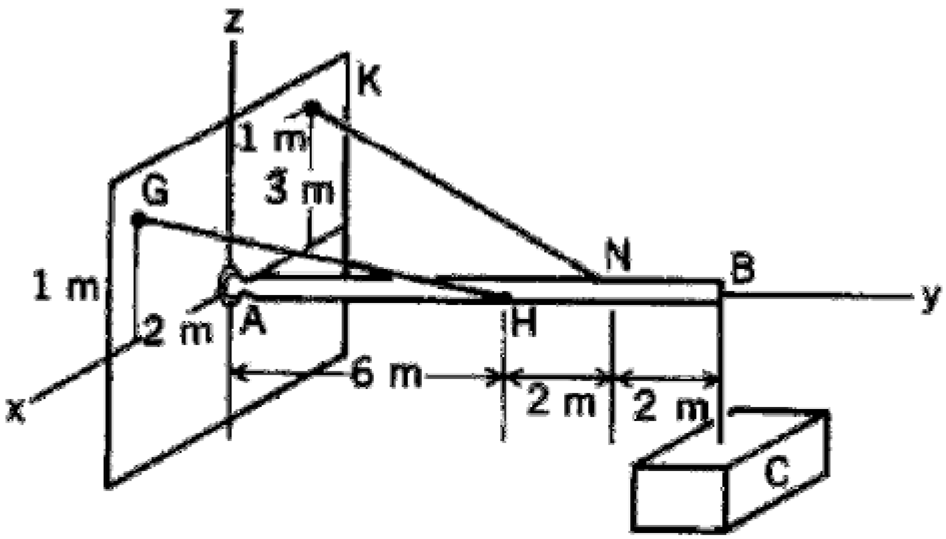


Figure 3

Solution:

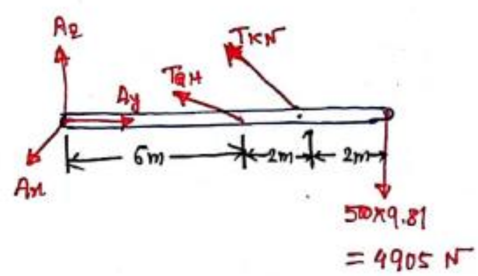
12)

$$\hat{HG} = \frac{\vec{HG}}{|\vec{HG}|} = \frac{2\hat{i} - 6\hat{j} + \hat{k}}{\sqrt{2^2+6^2+1^2}}$$

$$= \frac{2\hat{i} - 6\hat{j} + \hat{k}}{\sqrt{41}}$$

$$\hat{NK} = \frac{\vec{NK}}{|\vec{NK}|} = \frac{-\hat{i} - 8\hat{j} + 3\hat{k}}{\sqrt{1^2+8^2+3^2}}$$

$$= \frac{-\hat{i} - 8\hat{j} + 3\hat{k}}{\sqrt{74}}$$



$$\vec{T_{GH}} = T_{GH}\,\hat{HG} = \frac{T_{GH}}{\sqrt{41}}(2\hat{i} - 6\hat{j} + \hat{k})$$

$$\vec{T}_{KN} = T_{KN}\,\hat{NK} = \frac{T_{KN}}{\sqrt{74}}(-\hat{i} - 8\hat{j} + 3\hat{k})$$

$$\vec{A} + \vec{T}_{GH} + \vec{T}_{KN} - 4905\hat{k} = 0$$

$$\Rightarrow A_x\hat{i} + A_y\hat{j} + A_z\hat{k} + \frac{T_{GH}}{\sqrt{41}}(2\hat{i} - 6\hat{j} + \hat{k}) + \frac{T_{KN}}{\sqrt{74}}(-\hat{i} - 8\hat{j} + 3\hat{k}) - 4905\hat{k} = 0$$

$$\Rightarrow A_x + \frac{2}{\sqrt{41}}T_{GH} - \frac{1}{\sqrt{74}}T_{KN} = 0 \quad \text{(i)}$$

$$A_y - \frac{6}{\sqrt{41}}T_{GH} - \frac{8}{\sqrt{74}}T_{KN} = 0 \quad \text{(ii)}$$

$$A_z + \frac{1}{\sqrt{41}}T_{GH} + \frac{3}{\sqrt{74}}T_{KN} = 4905 \quad \text{(iv)}$$

$$\Sigma \vec{M}_A = 0$$

$$\Rightarrow 6\hat{j} \times \frac{T_{GH}}{\sqrt{41}}(2\hat{i} - 6\hat{j} + \hat{k}) + 8\hat{j} \times \frac{T_{KN}}{\sqrt{74}}(-\hat{i} - 8\hat{j} + 3\hat{k}) + 10\hat{j} \times (-4905\hat{k}) = 0$$

$$\Rightarrow \frac{12T_{GH}}{\sqrt{41}}(-\hat{k}) + \frac{6T_{GH}}{\sqrt{41}}\hat{i} + \frac{8T_{KN}}{\sqrt{74}}\hat{k} + \frac{24T_{KN}}{\sqrt{74}}\hat{i} - 49050\hat{i} = 0$$

$$\therefore \hat{k} \Rightarrow -\frac{12T_{GH}}{\sqrt{41}} + \frac{8T_{KN}}{\sqrt{74}} = 0 \Rightarrow T_{GH} = \frac{8\sqrt{41}}{12\sqrt{74}}T_{KN}$$

$$\hat{i} \Rightarrow \frac{6T_{GH}}{\sqrt{41}} + \frac{24T_{KN}}{\sqrt{74}} = 49050$$

$$\Rightarrow \left(\frac{6}{\cancel{\sqrt{41}}}\frac{8\cancel{\sqrt{41}}}{12\sqrt{74}} + \frac{24}{\sqrt{74}}\right)T_{KN} = 49050 \Rightarrow T_{KN} = \frac{49050\sqrt{74}}{28}$$

$$\Rightarrow T_{KN} = \underline{15,069.43\ N}$$

$$\therefore T_{GH} = \frac{8\sqrt{41}}{12\sqrt{74}}(15,069.43) = \underline{7477.93\ N}$$

$$\text{(i)} \Rightarrow A_x = \underline{-583.93\ N}$$

$$\text{(ii)} \Rightarrow A_y = \underline{21021.42\ N}$$

$$\text{(iii)} \Rightarrow A_z = \underline{-1518.21\ N}$$

4. Draw the free-body diagram of the foot lever shown in Fig.4 . The operator applies a vertical force to the pedal so that the spring is stretched 1.5 in. and the force in the short link at *B* is 20 lb.

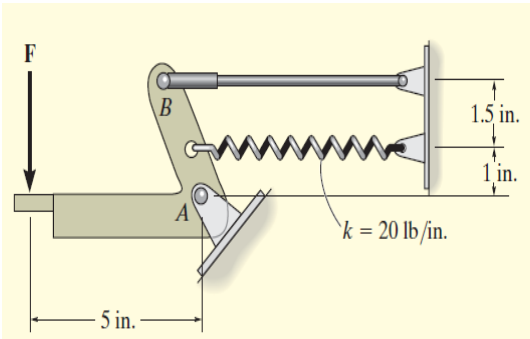
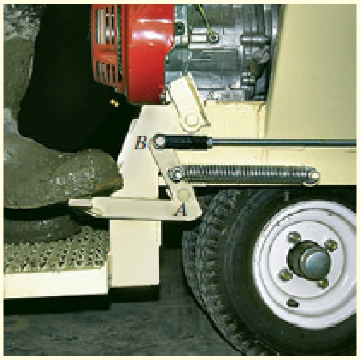


figure 4

Solution:

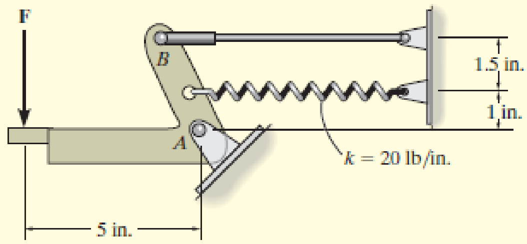
EXAMPLE 5.2

Draw the free-body diagram of the foot lever shown in Fig. 5–8*a*. The operator applies a vertical force to the pedal so that the spring is stretched 1.5 in. and the force in the short link at B is 20 lb.

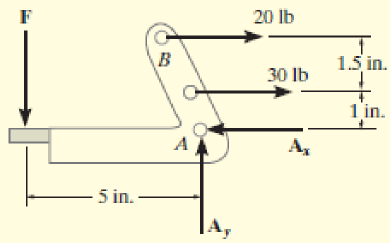


(a)

Fig. 5–8



(b)



(c)

SOLUTION

By inspection of the photo the lever is loosely bolted to the frame at A. The rod at B is pinned at its ends and acts as a "short link." After making the proper measurements, the idealized model of the lever is shown in Fig. 5–8*b*. From this, the free-body diagram is shown in Fig. 5–8*c*. The pin support at A exerts force components $\mathbf{A}_x$ and $\mathbf{A}_y$ on the lever. The link at B exerts a force of 20 lb, acting in the direction of the link. In addition the spring also exerts a horizontal force on the lever. If the stiffness is measured and found to be $k = 20$ lb/in., then since the stretch $s = 1.5$ in., using Eq. 3–2, $F_s = ks = 20$ lb/in. (1.5 in.) $= 30$ lb. Finally, the operator's shoe applies a vertical force of $\mathbf{F}$ on the pedal. The dimensions of the lever are also shown on the free-body diagram, since this information will be useful when computing the moments of the forces. As usual, the senses of the unknown forces at A have been assumed. The correct senses will become apparent after solving the equilibrium equations.