Department of Mechanical Engineering (NITC)

S1ME	**ZZ1001D ENGINEERING MECHANICS**	**Tutorial Test 4-Set1**
Time: One Hour	**Answer Key**	Maximum Marks: 20

1. Determine the horizontal and vertical components of reaction on the beam caused by the pin at *B* and the rocker at A as shown in Fig. 1. Neglect the weight of the beam.

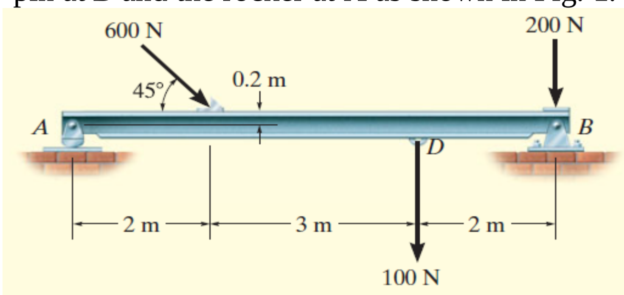


Figure 1

Solution:

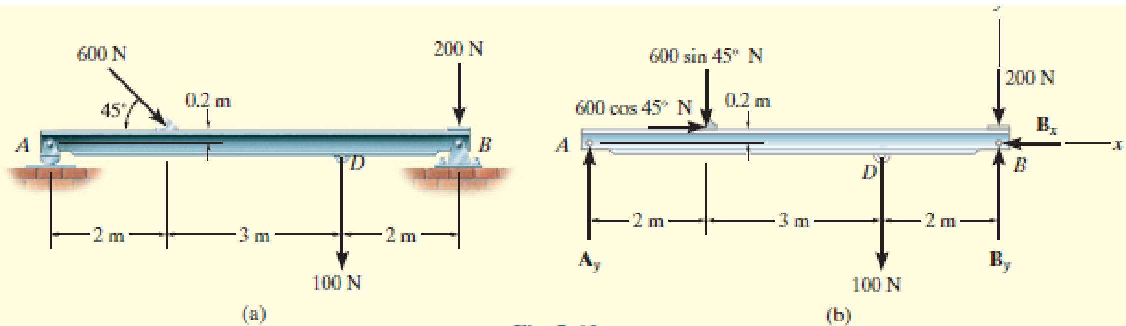


Fig. 5–12

SOLUTION

Free-Body Diagram. Identify each of the forces shown on the free-body diagram of the beam, Fig. 5–12*b*. (See Example 5.1.) For simplicity, the 600-N force is represented by its x and y components as shown in Fig. 5–12*b*.

Equations of Equilibrium. Summing forces in the x direction yields

$$\xrightarrow{+} \Sigma F_x = 0; \qquad 600 \cos 45^\circ \text{ N} - B_x = 0$$

$$B_x = 424 \text{ N} \qquad \textit{Ans.}$$

A direct solution for $\mathbf{A}_y$ can be obtained by applying the moment equation $\Sigma M_B = 0$ about point B.

$$\circlearrowleft + \Sigma M_B = 0; \qquad 100 \text{ N}(2 \text{ m}) + (600 \sin 45^\circ \text{ N})(5 \text{ m})$$
$$- (600 \cos 45^\circ \text{ N})(0.2 \text{ m}) - A_y(7 \text{ m}) = 0$$

$$A_y = 319 \text{ N} \qquad \textit{Ans.}$$

Summing forces in the y direction, using this result, gives

$$+\uparrow \Sigma F_y = 0; \qquad 319 \text{ N} - 600 \sin 45^\circ \text{ N} - 100 \text{ N} - 200 \text{ N} + B_y = 0$$

$$B_y = 405 \text{ N} \qquad \textit{Ans.}$$

NOTE: We can check this result by summing moments about point A.

$$\circlearrowleft + \Sigma M_A = 0; \qquad -(600 \sin 45^\circ \text{ N})(2 \text{ m}) - (600 \cos 45^\circ \text{ N})(0.2 \text{ m})$$
$$-(100 \text{ N})(5 \text{ m}) - (200 \text{ N})(7 \text{ m}) + B_y(7 \text{ m}) = 0$$

$$B_y = 405 \text{ N} \qquad \textit{Ans.}$$

2. A cantilever beam *AB* is pinned at *B* to a simply supported beam *BC* (Fig. 2). For the loads given, find the supporting force system at *A*. Determine force components that are normal and tangential to the cross-section of beam *AB*. Neglect the weights of the beams.

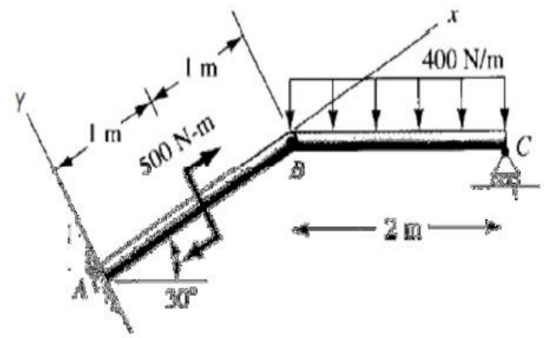
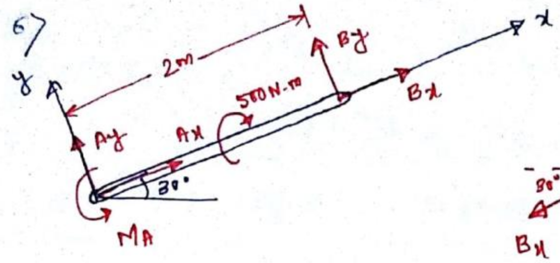


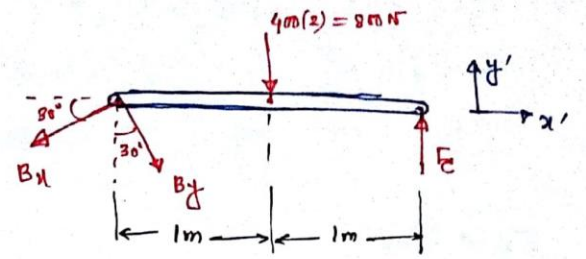
Figure 2

Solution:

6)



FBD I



FBD II

FBD II :

$\Sigma F_{x'} = 0 \Rightarrow \quad B_y \sin 30^\circ - B_x \cos 30^\circ = 0 \Rightarrow B_x = B_y \tan 30^\circ \quad$ (i)

$\Sigma M_B = 0 \Rightarrow \quad 2F_c = 800 \Rightarrow F_c = 400\ N \quad$ (ii)

$\Sigma F_{y'} = 0 \Rightarrow \quad B_x \sin 30^\circ + B_y \cos 30^\circ = F_c - 800 = -400$

$\Rightarrow B_x + \sqrt{3}\, B_y = -800$

$\Rightarrow \frac{1}{\sqrt{3}} B_y + \sqrt{3}\, B_y = -800 \quad$ (using (i))

$\Rightarrow \frac{4}{\sqrt{3}} B_y = -800 \Rightarrow B_y = -346.41\ N \quad$ (iii)

$\therefore \quad B_x = -346.41 \left(\frac{1}{\sqrt{3}}\right) = -200\ N \quad$ (iv) (from (i))

FBD I :

$\Sigma F_x = 0 \Rightarrow A_x = -B_x = \underline{200\ N}$

$\Sigma F_y = 0 \Rightarrow A_y = -B_y = \underline{+346.41\ N}$

$\Sigma M_A = 0 \Rightarrow M_A = 500 - 2B_y = 500 - 2(-346.41)$

$\Rightarrow M_A = \underline{1192.82\ N.m}$

Ans :

$A_x = 200\ N$

$A_y = 346.41\ N$

$M_A = 1192.82\ N.m$

3. What is the resultant of the force system transmitted across the section at *A* (Fig. 3)? The couple is parallel to plane *M*.

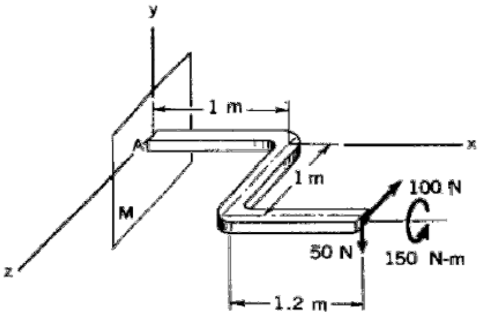
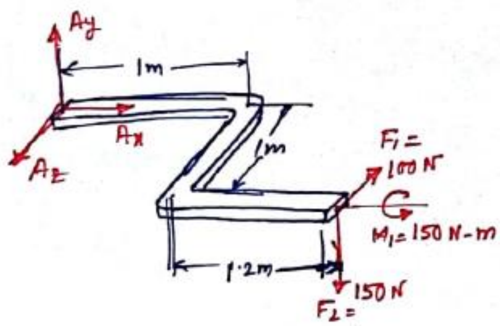


Figure 3

Solution:



1) $\vec{F_1} = -100\hat{k}$ N, $\vec{r_1} = 2.2\hat{i} + \hat{k}$ m

$\vec{F_2} = -50\hat{j}$ N, $\vec{r_2} = 2.2\hat{i} + \hat{k}$ m

$\vec{M_1} = 150\hat{i}$ N·m

$\Sigma \vec{F} = 0$

$\Rightarrow \vec{A} + \vec{F_1} + \vec{F_2} = 0$

$\Rightarrow A_x\hat{i} + A_y\hat{j} + A_z\hat{k} - 100\hat{k} - 50\hat{j} = 0$

$$\therefore \left.\begin{aligned} A_x &= 0 \\ A_y &= 50 \text{ N} \\ A_z &= 100 \text{ N} \end{aligned}\right\} \Rightarrow \underline{\vec{A} = 50\hat{j} + 100\hat{k} \text{ N}} \quad \text{Ans}$$

$\Sigma \vec{M_A} = 0$

$\Rightarrow \vec{M_A} + \vec{r_1}\times\vec{F_1} + \vec{r_2}\times\vec{F_2} + \vec{M_1} = 0$

$\Rightarrow \vec{M_A} = -(2.2\hat{i} + \hat{k})\times(-100\hat{k}) - (2.2\hat{i} + \hat{k})\times(-50\hat{j}) - 150\hat{i}$

$= -220\hat{j} + 110\hat{k} - 150\hat{i} - 50\hat{i}$

$\Rightarrow \underline{\vec{M_A} = -200\hat{i} - 220\hat{j} + 110\hat{k} \text{ N.m}}$ Ans

4. Determine the tension in cables *BD* and *CD* and the *x, y, z* components of reaction at the ball-and socket joint at *A* (Fig. 4).

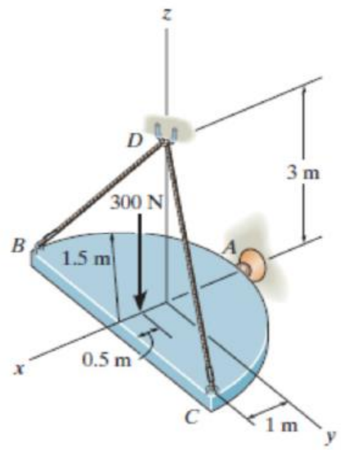
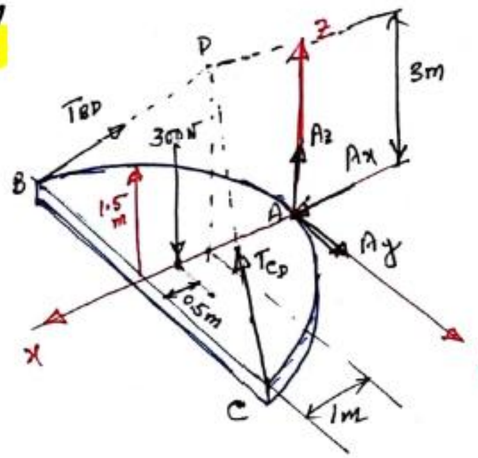


Figure 4

Solution:



16) $\vec{BD} = \left(-1\hat{i} + 1.5\hat{j} + 3\hat{k}\right)$ m

$|\vec{BD}| = 3.5\text{m}$

$\hat{BD} = \dfrac{\vec{BD}}{|\vec{BD}|}$

$= -0.2857\,\hat{i} + 0.4286\,\hat{j} + 0.8571\,\hat{k}$

$\therefore\ \vec{T}_{BD} = T_{BD}\,\hat{BD} = -0.2857\,T_{BD}\,\hat{i} + 0.4286\,T_{BD}\,\hat{j} + 0.8571\,T_{BD}\,\hat{k}$

Similarly,

$\vec{T}_{CD} = -0.2857\,T_{CD}\,\hat{i} - 0.4286\,T_{CD}\,\hat{j} + 0.8571\,T_{CD}\,\hat{k}$

Thus, using the components of T_{BD} and T_{CD}, the scalar equations of equilibrium become:

$\Sigma F_x = 0 \Rightarrow \quad A_x - 0.2857\,T_{BD} - 0.2857\,T_{CD} = 0$

$\Sigma F_y = 0 \Rightarrow \quad A_y + 0.4286\,T_{BD} - 0.4286\,T_{CD} = 0$

$\Sigma F_z = 0 \Rightarrow \quad A_z + 0.8571\,T_{BT} + 0.8571\,T_{CD} - 300 = 0$

$\Sigma (M_A)_x = 0 \Rightarrow \quad -(1.5) \times (0.8571\,T_{BD}) + (1.5)(0.8571\,T_{CD}) = 0$

$\Sigma (M_A)_y = 0 \Rightarrow \quad 1\times 300 - 1.5(0.8571\,T_{BD}) - 1.5(0.8571\,T_{CD}) = 0$

solving

$$\left.\begin{aligned} T_{BD} &= T_{CD} = 117\text{ N} \\ A_x &= 66.7\text{ N} \\ A_y &= 0 \\ A_z &= 100\text{ N} \end{aligned}\right\} \text{Ans}$$