Given:

3-15 A farmer is extracting a post from the ground using the structure shown in Fig. P3-15. What force must the farmer apply to the cable system if the force required to remove the post is 2000 lb?

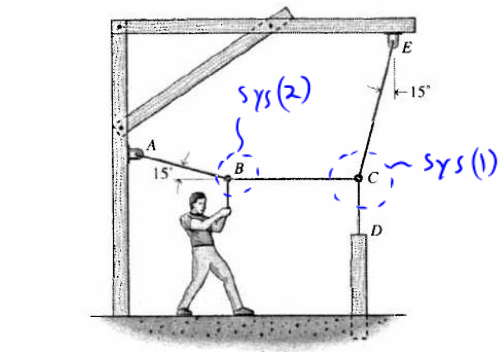


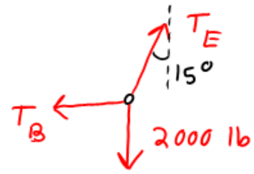
Figure P3-15

Find: $\vec{F}$ that farmer pulls on cable

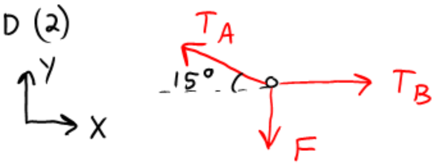
System: (1) pt C (2) pt B

Solution: First, draw the FBDs

FBD(1)



FBD (2)



Now, use equilibrium on each system

sys (1) $\quad \Sigma F_y = 0$

$$T_E \cos 15^\circ - 2000 \text{ lb} = 0 \qquad \therefore T_E = \frac{2000 \text{ lb}}{\cos 15^\circ} = 2071 \text{ lb}$$

$\Sigma F_x = 0$

$$-T_B + T_E \sin 15^\circ = 0 \qquad \therefore T_B = T_E \sin 15^\circ$$
$$= (2071 \text{ lb}) \sin 15^\circ = 535.9 \text{ lb}$$

sys (2) $\quad \Sigma F_x = 0$

$$T_B - T_A \cos 15^\circ = 0 \qquad \therefore T_A = \frac{T_B}{\cos 15^\circ} = \frac{535.9 \text{ lb}}{\cos 15^\circ} = 554.8 \text{ lb}$$

$\Sigma F_y = 0$

$$T_A \sin 15^\circ - F = 0 \qquad \therefore F = T_A \sin 15^\circ = (554.8 \text{ lb}) \sin 15^\circ$$
$$= 143.6 \text{ lb}$$

so the farmer must apply a force of

$$\boxed{\vec{F} = -143.6 \text{ lb } \hat{j}}$$

Given:

3-38* A 1250-N force **F** is supported by a cable *AD* and by struts *AB* and *AC*, as shown in Fig. P3-38. If the struts can transmit only axial tensile or compressive forces, determine the forces in the struts and the tension in the cable.

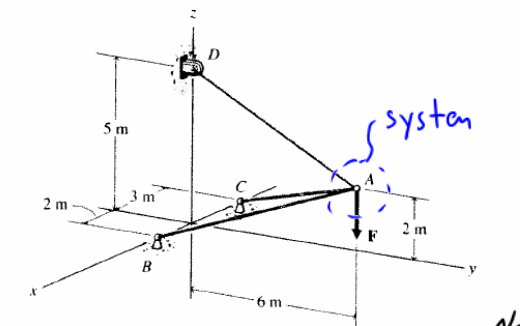


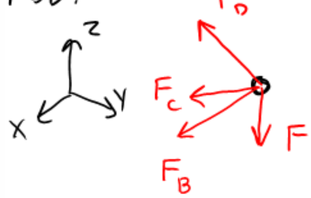
Figure P3-38

Find: $\vec{F}_B$, $\vec{F}_c$, T_D

System: point A only

Solution:

FBD:



Coordinates are:
A @ (0, 6, 2) m
B @ (2, 0, 0) m
C @ (-3, 0, 0) m
D @ (0, 0, 5) m

Now, find directions of each force

for T_D
$$\vec{r}_{AD} = pt\,D - pt\,A = \begin{bmatrix}0\\0\\5\end{bmatrix} - \begin{bmatrix}0\\6\\2\end{bmatrix} m = \begin{bmatrix}0\\-6\\3\end{bmatrix} m \qquad |\vec{r}_{AD}| = \sqrt{0^2+(-6)^2+3^2}\ m = \sqrt{45}\ m$$

$$\vec{T}_D = T_D\,\frac{0\hat{\imath} - 6\hat{\jmath} + 3\hat{k}\ m}{\sqrt{45}\ m} = T_D\left(0\hat{\imath} - 0.8944\hat{\jmath} + 0.4472\hat{k}\right)$$

for F_c
$$\vec{r}_{AC} = pt\,C - pt\,A = \begin{bmatrix}-3\\0\\0\end{bmatrix} - \begin{bmatrix}0\\6\\2\end{bmatrix} m = \begin{bmatrix}-3\\-6\\-2\end{bmatrix} m \qquad |\vec{r}_{AC}| = \sqrt{(-3)^2+(-6)^2+(-2)^2}\ m = 7\ m$$

$$\vec{F}_c = F_c\,\frac{-3\hat{\imath} - 6\hat{\jmath} - 2\hat{k}\ m}{7\ m} = F_c\left(-0.4286\hat{\imath} - 0.8571\hat{\jmath} - 0.2857\hat{k}\right)$$

for F_B
$$\vec{r}_{AB} = pt\,B - pt\,A = \begin{bmatrix}2\\0\\0\end{bmatrix} - \begin{bmatrix}0\\6\\2\end{bmatrix} m = \begin{bmatrix}2\\-6\\-2\end{bmatrix} m \qquad |\vec{r}_{AB}| = \sqrt{2^2+(-6)^2+(-2)^2}\ m = \sqrt{44}\ m$$

$$\vec{F}_B = F_B\,\frac{2\hat{\imath} - 6\hat{\jmath} - 2\hat{k}\ m}{\sqrt{44}\ m} = F_B\left(0.3015\hat{\imath} - 0.9045\hat{\jmath} - 0.3015\hat{k}\right)$$

Now, apply equilibrium eqns

$$\Sigma F_x = 0: \quad T_{Dx} + F_{cx} + F_{Bx} + \cancelto{0}{F_x} = 0$$
$$T_D(0) + F_c(-0.4286) + F_B(0.3015) = 0 \qquad \text{(eq 1)}$$

$$\Sigma F_y = 0: \quad T_{Dy} + F_{cy} + F_{By} + \cancelto{0}{F_y} = 0$$
$$T_D(-0.8944) + F_c(-0.8571) + F_B(-0.9045) = 0 \qquad \text{(eq 2)}$$

$$\Sigma F_z = 0: \quad T_{Dz} + F_{cz} + F_{Bz} + F_z = 0$$
$$T_D(0.4472) + F_c(-0.2857) + F_B(-0.3015) - 1250\ N = 0 \qquad \text{(eq 3)}$$

we have 3 eqns and 3 unknowns (T_D, F_c, F_B) solve using MAPLE - see attached

$$\boxed{T_D = 1677\ N}$$

$F_c = -700\ N$ ← so the force is drawn backwards in the FBD

$F_B = -995\ N$

plugging F_c & F_B into the component expressions

$$\vec{F}_C = (-700\text{ N})(-0.4286\,\hat{\imath} - 0.8571\,\hat{\jmath} - 0.2857\,\hat{k})$$

$$\boxed{\vec{F}_C = 300\,\hat{\imath} + 600\,\hat{\jmath} + 200\,\hat{k}\text{ N}}$$ ~ the force of the strut on pt A

$$\vec{F}_B = (-995\text{ N})(0.3015\,\hat{\imath} - 0.9045\,\hat{\jmath} - 0.3015\,\hat{k})$$

$$\boxed{\vec{F}_B = -300\,\hat{\imath} + 900\,\hat{\jmath} + 300\,\hat{k}\text{ N}}$$ ~ the force of the strut on pt A