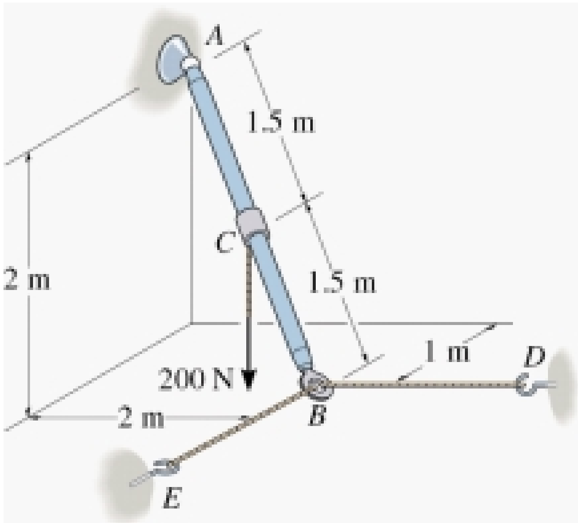
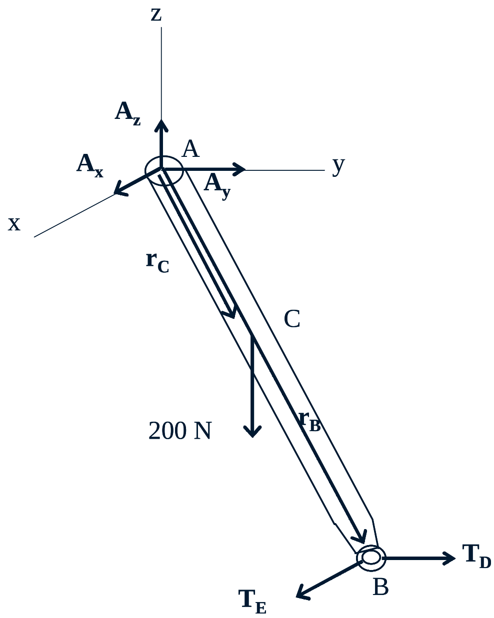
Problem 1:

Rod AB is subjected to the 200-N force. Determine the reactions at the ball-and-socket joint A and the tension in cables BD and BE.



Solution:



Equations of Equilibrium

$$F_A = A_x i + A_y j + A_z k$$

$$T_E = T_E i$$

$$T_D = T_D j$$

$$F = \{-200k\}N$$

Apply the force equation of equilibrium

$$\sum F = 0$$

$$\Rightarrow F_A + T_E + T_D + F = 0$$

$$\Rightarrow (A_x + T_E)i + (A_y + T_D)j + (A_z - 200)k = 0$$

$$\sum F_x = 0 \Rightarrow A_x + T_E = 0 \qquad (1)$$

$$\sum F_y = 0 \Rightarrow A_y + T_D = 0 \qquad (2)$$

$$\sum F_z = 0 \Rightarrow A_z - 200 = 0 \qquad (3)$$

Summing moments about point A yields

$$\sum M_A = 0 \Rightarrow r_C \times F + r_B \times (T_E + T_D) = 0$$

Since $r_C = \frac{r_B}{2}$, then

$$(0.5i + 1j - 1k) \times (-200k) + (1i + 2j - 2k) \times (T_E i + T_D j) = 0$$

$$(0.5i + 1j - 1k) \times (-200k) + (1i + 2j - 2k) \times (T_E i + T_D j) = 0$$

Expanding and rearranging terms gives

$$(2T_D - 200)i + (-2T_E + 100)j + (T_D - 2T_E)k = 0$$

$$\sum M_x = 0 \Rightarrow 2T_D - 200 = 0 \qquad (4)$$

$$\sum M_y = 0 \Rightarrow -2T_E + 100 = 0 \qquad (5)$$

$$\sum M_z = 0 \Rightarrow T_D - 2T_E = 0 \qquad (6)$$

$$\sum F_x = 0 \Rightarrow A_x + T_E = 0 \qquad (1)$$

$$\sum F_y = 0 \Rightarrow A_y + T_D = 0 \qquad (2)$$

$$\sum F_z = 0 \Rightarrow A_z - 200 = 0 \qquad (3)$$

$$\sum M_x = 0 \Rightarrow 2T_D - 200 = 0 \qquad (4)$$

$$\sum M_y = 0 \Rightarrow -2T_E + 100 = 0 \qquad (5)$$

$$\sum M_z = 0 \Rightarrow T_D - 2T_E = 0 \qquad (6)$$

Solving Equations 1 through 6, we get

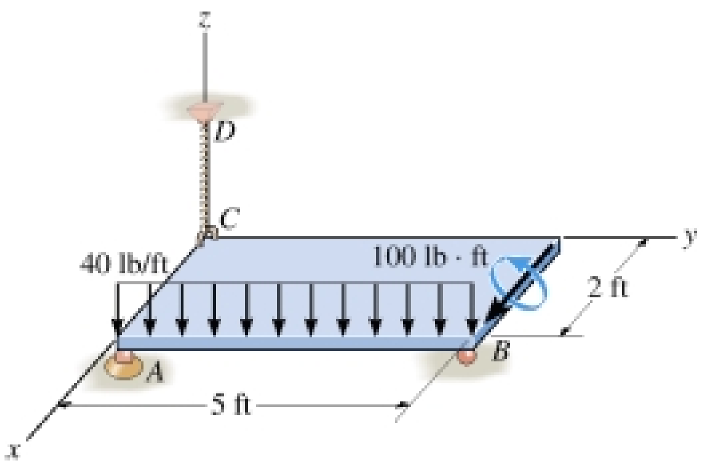
$T_D = 100N \qquad T_E = 50N$

$A_x = -50N \qquad A_y = -100N$

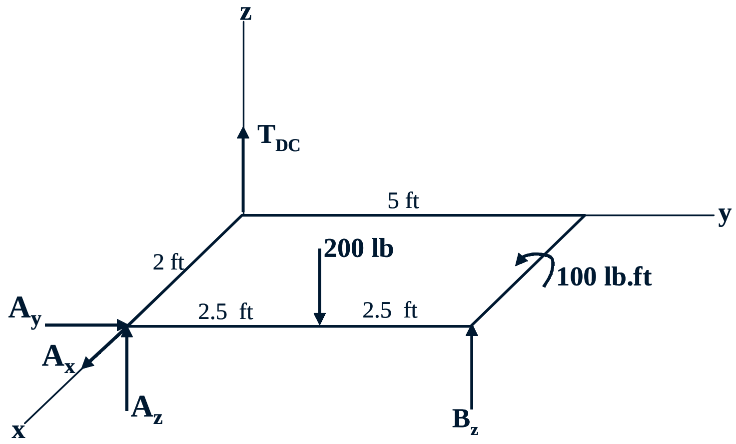
$A_z = 200N$

Problem 2:

Determine the x, y, z components of reaction acting on the ball-and-socket at A, the reaction at the roller B, and the tension in the cord CD required for equilibrium of the plate.



Solution:
The FBD is:



$$\sum M_x = 0$$
$$\Rightarrow 100 + B_z(5) - 200(2.5) = 0$$
$$\Rightarrow B_z = 80 \text{ lb}$$

$$\sum M_y = 0$$
$$\Rightarrow 200(2) - A_z(2) - 80(2) = 0$$
$$\Rightarrow A_z = 120 \text{ lb}$$
$$\sum F_z = 0$$
$$\Rightarrow 80 + 120 - 200 + T_{CD} = 0$$
$$\Rightarrow T_{CD} = 0 \text{ lb}$$

$$\sum F_x = 0$$
$$\Rightarrow A_x = 0$$

$$\sum F_y = 0$$
$$\Rightarrow A_y = 0$$

Problem 3:

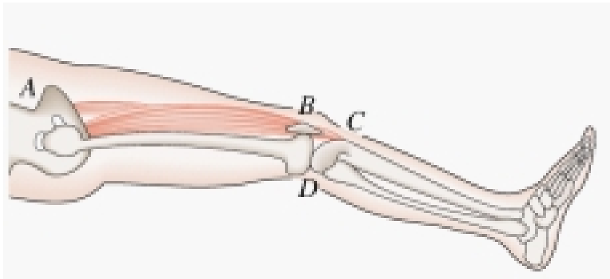
A skeletal diagram of the lower leg is shown.

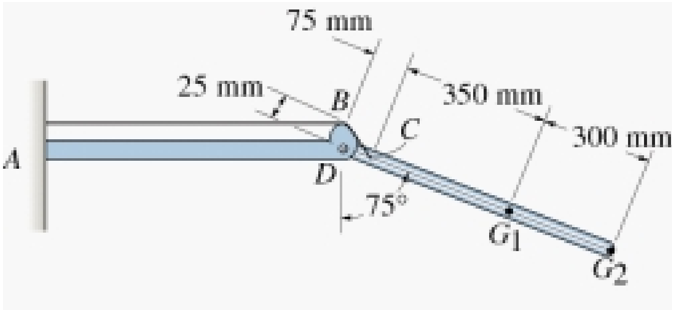
The quadriceps muscle attached to the hip at A and to the patella bone at B lift the leg. This bone slides freely over cartilage at the knee joint.

The quadriceps is further extended and attached to the tibia at C.

Determine the tension T in the quadriceps at C and the magnitude of the resultant force at the (femur) pin, D, in order to hold the lower leg.

The lower leg has a mass of 3.2 kg and a mass center at G1; the foot has a mass of 1.6 kg and a mass center at G2.



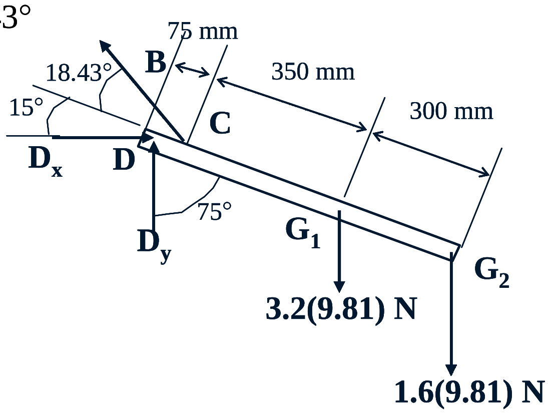


Solution:

The FBD is:

$$\tan^{-1}\left(\frac{25}{75}\right) = 18.43°$$

$$90° - 75° = 15°$$



$$\circlearrowleft + \sum M_D = 0$$

$$T \sin 18.43°(75) - 3.2(9.81)(425 \sin 75°) - 1.6(9.81)(725 \sin 75°) = 0$$

$$\Rightarrow T = 1006.82 N = 1.01 kN$$

$$+\uparrow \sum F_y = 0$$

$$D_y + 1006.82 \sin 33.43° - 3.2(9.81) - 1.6(9.81) = 0$$

$$\Rightarrow D_y = -507.66 N$$

$$\xrightarrow{+} \sum F_x = 0$$

$$D_x - 1006.82 \cos 33.43° = 0$$

$$\Rightarrow D_x = 840.20N$$

$$F_D = \sqrt{D_x^2 + D_y^2} = \sqrt{(-507.66)^2 + (840.20)^2}$$

$$\Rightarrow F_D = 982N$$