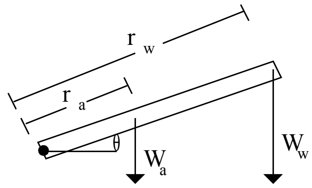
Chapter 12 Problem 27 †

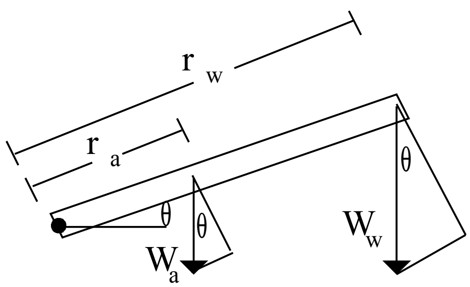


Given

$W_a = 4.2\ kg$
$r_a = 0.21\ m$
$W_w = 6.0\ kg$
$r_w = 0.56\ m$
$\theta = 15°$

Solution

a) Find the torque due to the weight of the arm and the mass.



The component of the weight that is perpendicular to the force arm is the weight times $\cos\theta$. Therefore, the torque is

$$\tau = \tau_a + \tau_w = -r_a W_a \cos\theta - r_w W_w \cos\theta$$

The torques are negative since they are in a clockwise direction.

$$\tau = -g\cos\theta(r_a m_a + r_w m_w)$$

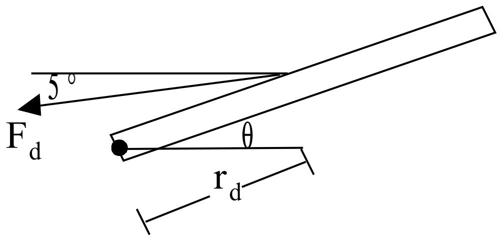
$$\tau = -(9.80\ m/s^2)\cos(15°)\left((0.21\ m)(4.2\ kg) + (0.56\ m)(6.0\ kg)\right)$$

$$\tau = -40.2\ N\cdot m$$

b) Find the force exerted by the deltoid.

The deltoid acts at an angle of 5° below horizontal. That means it exerts a force at an angle of 10° with respect to the bone.

†Problem from Essential University Physics, Wolfson



The torque provided by the deltoid must offset the torque exerted by the mass and the weight of the arm.

$$\tau_d = r_d F_d \sin\theta_d$$

The sine function is used here since it gives the component of the deltoid force perpendicular to the force arm. Now solve for F_d.

$$F_d = \frac{\tau_d}{r_d \sin\theta_d} = \frac{40.2\ N \cdot m}{(0.18\ m)\sin(10^\circ)} = 1290\ N$$

$$F_d = 1.29\ kN$$