# Physics 151 Class Exercise: Torque 3

1. A bodybuilder holds a dubmbell of weight W_d as shown in the diagram. His arm is extended horizontally and weighs W_a = 31.0 N. The deltoid muscle is assumed to be the only muscle acting and is attached to the arm as shown. The maximum force M that the deltoid muscle can supply to keep the arm horizontal has a magnitude of 1840 N. The freebody diagram below illustrates the distances where the various forces act on the arm. What is the weight of the heaviest dumbbell that can he held and what are the horizontal and vertical force components, S_x and S_y, that the shoulder joint applies to the left end of the arm?
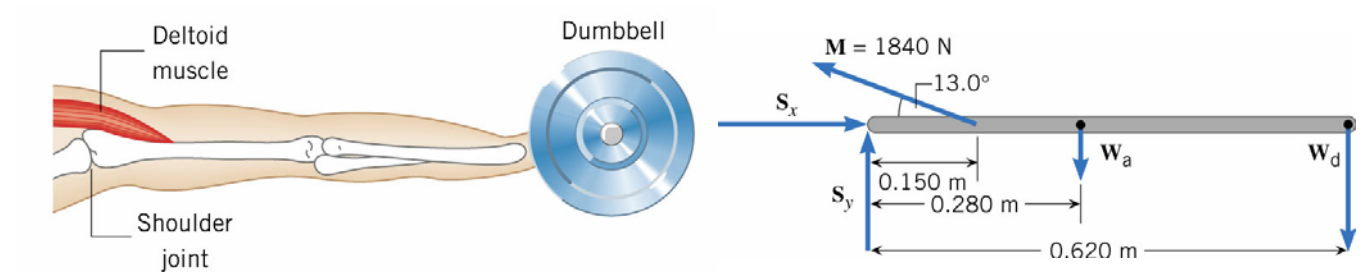
The arm is in equilibrium, so the net force and net torque on it are zero.

$$\Sigma \tau_{shoulder} = M\left(\sin 13°\right)\left(0.150m\right) - W_a\left(0.280m\right) - W_d\left(0.620m\right) = 0$$

$$W_d = \frac{M\left(\sin 13°\right)\left(0.150m\right) - W_a\left(0.280m\right)}{\left(0.620m\right)} = \frac{\left(1840N\right)\left(\sin 13°\right)\left(0.150m\right) - \left(31.0m\right)\left(0.280m\right)}{\left(0.620m\right)} = 86.1N$$

$$\Sigma F_x = S_x - M\cos 13° = 0$$
$$S_x = M\cos 13° = \left(1840N\right)\cos 13° = 1790N$$
$$\Sigma F_y = S_y + M\sin 13° - W_a - W_d = 0$$
$$S_y = W_a + W_d - M\sin 13° = \left(31.0N\right) + \left(86.1N\right) - \left(1840N\right)\sin 13° = -297$$

Thus, our FBD has S_y pointed in the wrong direction.

2. A wrecking ball (weight = 4800 N) is supported by a boom, which may be assumed to be uniform and has a weight of 3600 N. As the figure shows, a support cable runs from the top of the boom to the tractor. The angle between the support cable and the horizontal is 32°, and the angle between the boom and the horizontal is 48°. Find the tension in the support cable.

(Hint: First draw a freebody diagram for the boom and label all relevant angles in the problem.)
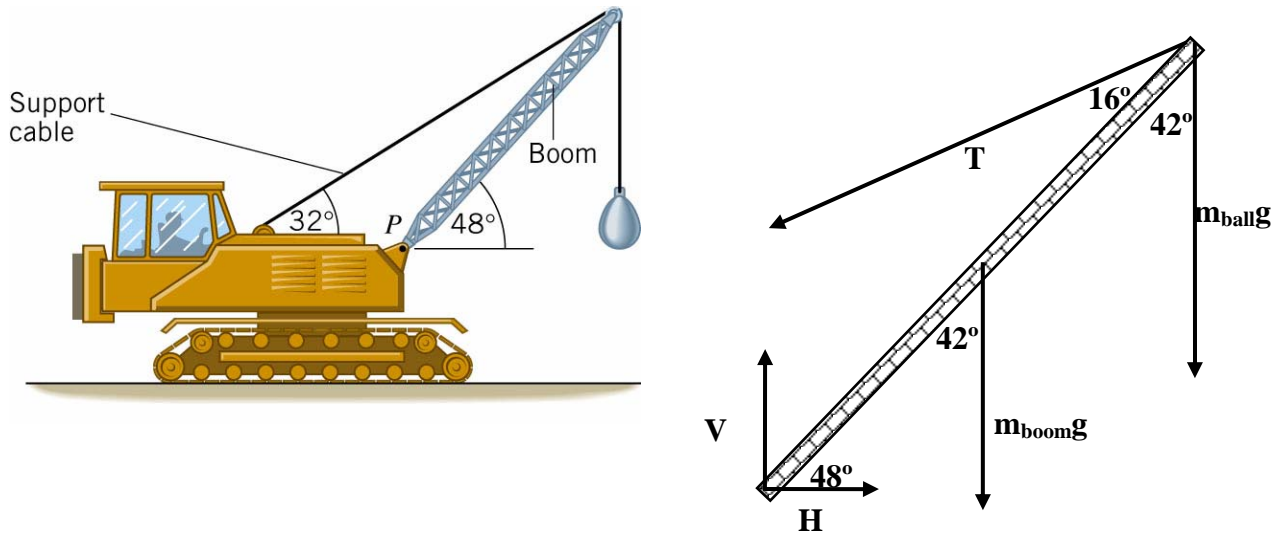
$$\Sigma \tau_P = T \sin 16° l - m_{ball} g \sin 42° l - m_{boom} g \sin 42° \frac{l}{2} = 0$$

$$T = \frac{g \sin 42° \left(m_{ball} + \frac{m_{boom}}{2} \right)}{\sin 16°} = \frac{\sin 42°}{\sin 16°} \left[(4800N) + \frac{(3600N)}{2} \right] = 16,000N$$