

Ch 7 1, 21, 47

A discus thrower makes a full revolution in 1 second before releasing the discus. The diameter of the circle the discus makes before release is 1.8m. If the thrower starts from rest, what will the speed be on release?

Method 1

Can approach a couple of different ways. You could find the angular acceleration ( $\alpha$ ); then the final angular speed ( $\omega$ ) and finally the speed ( $v$ ).

$$\Delta\theta = 2\pi \text{ rad} \quad \Delta t = 1.0 \text{ s} \quad \omega_i = 0 \text{ rad/s}$$

$$2 \frac{\Delta\theta}{\Delta t^2} = \alpha = \frac{2(2\pi)}{(1.0)^2} = 4\pi \text{ rad/s}^2$$

$$\omega_f = \omega_i + \alpha \Delta t = 0 \text{ rad/s} + 4\pi \text{ rad/s}^2 (1.0) = 4\pi \text{ rad/s}$$

$$v = \omega r = 4\pi \text{ rad/s} (0.9 \text{ m}) = \underline{11.3 \text{ m/s}}$$

Method 2

Another approach would be to say  $\overline{v} = \frac{\Delta x}{\Delta t} = \frac{2\pi}{1.0} = 2\pi$

Average speed is  $\frac{2\pi (0.9 \text{ m})}{1.0 \text{ s}} = 5.65 \text{ m/s}$

If it starts at rest & averages 5.65 m/s it must be going twice the average at the end so

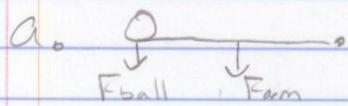
$$v = \underline{11.3 \text{ m/s.}} \quad \text{You can check this by saying } v_{\text{avg}} = \frac{v_i + v_f}{2} = \frac{0 + 11.3 \text{ m/s}}{2} = 5.65 \text{ m/s}$$

## Ch 7 #21

An athlete holds a 3.0kg steel ball in his hand. His arm is 70cm long and has a mass of 4.0kg. What is the magnitude of the torque about his shoulder if he holds his arm

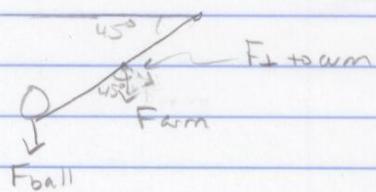
a. straight out parallel to the floor

b. straight but  $45^\circ$  below the horizontal



$$\begin{aligned} \text{center of mass of arm} \\ \text{ET} &= F_{\text{arm}} 0.35\text{m} + F_{\text{ball}} 0.70\text{m} = T_{\text{net}} \\ &= 4.0\text{kg} 9.8\text{m/s}^2 0.35\text{m} + 3.0\text{kg} 9.8\text{m/s}^2 0.70\text{m} \\ &= 13.7\text{ Nm} + 20.6\text{ Nm} \\ &= \boxed{34\text{ Nm}} \end{aligned}$$

b.



$$\begin{aligned} \text{ET} &= F_{\text{arm}} \sin 45^\circ 0.35\text{m} + F_{\text{ball}} \sin 45^\circ 0.70\text{m} \\ &= 4.0\text{kg} 9.8\text{m/s}^2 \sin 45^\circ 0.35\text{m} + 3.0\text{kg} 9.8\text{m/s}^2 \sin 45^\circ 0.70\text{m} \\ &= 9.69\text{ Nm} + 14.6\text{ Nm} \\ &= \boxed{24\text{ Nm}} \end{aligned}$$

Notice the torque is less when the same arm w/ the same object in the same location is simply lowered to an angle of  $45^\circ$ .

This is why trees grow at an angle. Horizontal branches break more easily because torques are larger for the same load!

## Ch 7 #47

A car with 58-cm-diameter tires accelerates uniformly from rest to 20 m/s in 10 s. How many times does each tire rotate?

This problem has several productive approaches.

Method 1 You could find the distance the car travels and then how far the car goes in one tire rotation, finally divide the distance of one rotation into the total distance covered.

$$V_f = V_i + at \quad a = \frac{20 \text{ m/s} - 0 \text{ m/s}}{10 \text{ s}} = 2.0 \text{ m/s}^2$$

$$X = X_i + V_i t + \frac{1}{2} a t^2 \quad X = 0 + 2.0 \text{ m/s} (10 \text{ s})^2 = 100 \text{ m}$$

One tire covers its circumference in one full revolution. (Each part of the tire touches the ground as it goes around)

$$C = 2\pi r = 2\pi \cdot 0.29 \text{ m} = 1.82 \text{ m}$$

$$\# \text{ revolutions} = \frac{\text{Distance}}{\text{Distance/rev}} = \frac{100 \text{ m}}{1.82 \text{ m}} = \boxed{55 \text{ revolutions}}$$

Method 2 You could find the angular distance ( $\theta$ ) covered during the 10 seconds by finding the angular acceleration. Then convert to revolutions from radians.

$$\omega_f = V_f / r = 20 \text{ m/s} / 0.29 \text{ m} = 68.97 \text{ rad/s}$$

$$\alpha = \frac{\omega_f - \omega_i}{\Delta t} = \frac{68.97 \text{ rad/s} - 0}{10 \text{ s}} = 6.897 \text{ rad/s}^2$$

$$\theta = \theta_i + \omega_i t + \frac{1}{2} \alpha t^2 = \frac{1}{2} 6.897 \text{ rad/s}^2 (10 \text{ s})^2 = 345 \text{ rad}$$

$$345 \text{ rad} \left( \frac{1 \text{ rev}}{2\pi \text{ rad}} \right) = \boxed{55 \text{ rev}}$$