



Assignment 8.01 - Centripetal Force and Acceleration KEY

1. A carnival ride has a circular wheel with a radius of 3 meters. It rotates with a tangential velocity of 10 m/s. What is the acceleration that a person on this ride will feel?

$$a_c = \frac{v^2}{r} = \frac{(10\text{m/s})^2}{3\text{m}} = 33.333\text{m/s}^2$$

2. You are swinging a bucket of water around in a vertical circle, with a radius of 1 meter.

- (a) What is the minimum velocity you must swing the bucket with in order to keep the water in the bucket?

$$a_c = \frac{v^2}{r} \implies v = \sqrt{a_c r} = \sqrt{(9.81\text{m/s}^2)(1\text{m})} \approx 3.132\text{m/s}$$

- (b) How long would it take to make one full rotation?

$$v = \frac{d}{t} \implies t = \frac{d}{v} = \frac{c}{v} = \frac{2\pi r}{v} = \frac{2 \cdot \pi \cdot 1\text{m}}{3.132\text{m/s}} \approx 2.006\text{s}$$

3. A compact disk will shatter if its rotational rate exceeds 28,000 rotations per minute. A CD has a radius of 0.08 meters.

- (a) Calculate the speed at which the CD will shatter.

$$v = \frac{d}{t} = \frac{28000 \cdot c}{t} = \frac{28000 \cdot 2 \cdot \pi \cdot r}{t} = \frac{28000 \cdot 2 \cdot \pi \cdot 0.08\text{m}}{60\text{s}} \approx 234.572\text{m/s}$$

- (b) A section of CD, at a distance of 7 cm from the center of the disk has a mass of 1.2 grams. What is the force on this section of the CD?

Note that the radius has changed, and thus the speed must be calculated again.

$$v = \frac{d}{t} = \frac{28000 \cdot c}{t} = \frac{28000 \cdot 2 \cdot \pi \cdot r}{t} = \frac{28000 \cdot 2 \cdot \pi \cdot 0.07\text{m}}{60\text{s}} \approx 205.251\text{m/s}$$
$$F_c = \frac{mv^2}{r} = \frac{.0012\text{kg} \cdot 205.251\text{m/s}}{.07\text{m}} \approx 722.192\text{N}$$



4. In a move, Batman holds on to a helicopter rotor as it spins, before climbing into the helicopter. The helicopter has blades that are 4 meters long, and rotate 3 times per second.

(a) What is the circumference of the circle made by the helicopter blades?

The length of the blade is the radius. Therefore, the circumference is:

$$c = 2\pi r = 2\pi \cdot 4m \approx 25.133m$$

(b) What is the velocity that the blades rotate with?

$$v = \frac{d}{t} = \frac{3c}{t} = \frac{3 \cdot 25.133m}{1s} \approx 75.398m/s$$

(c) What is the acceleration that batman feels? How many g's is this?

$$a_c = \frac{v^2}{r} = \frac{(75.398m/s)^2}{4m} \approx 1421.215m/s^2$$
$$a_c = \frac{1421.215m/s^2}{9.81m/s^2} \approx 144.874 \text{ g's}$$

(d) If batman has a mass of 80 kg, what is the force that he feels?

$$F = ma = 80kg \cdot 1421.215m/s^2 \approx 11589.925N$$

(e) What happens to Batman?

Batman dies.

5. A penny is placed on top of a horizontal turntable, 5 cm from the axis of rotation. The coefficient of friction between the turntable and the penny is 0.25. If the mass of the penny is 0.0025 kg, at what speed would the turntable cause the penny to slide off?

At low speeds, static friction provides the centripetal force for the penny to stay on the turntable. As the turntable speeds up, the amount of centripetal force required to stay on the turntable exceeds what friction can provide, and the penny slides off. Therefore:

$$F_c \geq F_f$$
$$\frac{mv^2}{r} \geq \mu mg$$
$$v \geq \sqrt{\mu gr} = \sqrt{0.25 \cdot 9.81m/s^2 \cdot 0.05m} \approx 0.350m/s$$