Uniform Circular Motion

Motion in _____ with constant _____

Rotation Angle (Δθ)

_____ through which an object _____

Arc Length (Δs)

- _____ around part of a _____

$$\Delta\theta = \frac{\Delta s}{r}$$

Angle Units

- 1 Circle = 1 revolution
- 1 Circle = 360°
- 1 Circle = 2π radians

Arc length must be in _____

Convert 60° to radians

Convert 2 revolutions to radians

Angular Velocity (ω)

How fast an object _____

$$\omega = \frac{\Delta\theta}{\Delta t}$$

Unit: rad/s CCW_____ CW_____

$$v = r\omega$$

A CD rotates 320 times in 2.4 s. What is its angular velocity in rad/s? What is the linear velocity of a point 5 cm from the center?

Centripetal Acceleration

$$a_c = \frac{v^2}{r} = r\omega^2$$

At any given moment

    v is pointing _____ to the circle

    a_c is pointing towards the _____ of the circle

If the object suddenly broke from circular motion would travel in _____ _____ to circle

Two identical cars are going around two corners at 30 m/s. Each car can handle up to 1 g. The radius of the first curve is 50m and the radius of the second is 100 m. Do either of the cars make the curve? (Hint: find the a_c)

1. The speedometer of your car shows you are traveling at a constant speed of 35 m/s. Is it possible that your car is accelerating? If so, explain how this could happen.

2. The equations of kinematics describe the motion of an object that has a constant acceleration. These equations cannot be applied to uniform circular motion. Why not?

3. Is it possible for an object to have an acceleration when the velocity of the object is constant? When the speed of the object is constant? In each case, give your reasoning.

4. There is an analogy between rotational and linear physical quantities. What rotational quantities are analogous to distance and velocity?

5. Can centripetal acceleration change the speed of circular motion? Explain.

6. Microwave ovens rotate at a rate of about 6 rev/min. (a) What is this in revolutions per second? (b) What is the angular velocity in radians per second? (OpenStax 6.2) **0.1 rev/s, 0.63 rad/s**

7. (a) What is the period of rotation of Earth in seconds? (b) What is the angular velocity of Earth? (c) Given that Earth has a radius of 6.4×10^6 m at its equator, what is the linear velocity at Earth's surface? (OpenStax 6.4) **86400 s, 7.3×10^{-5} rad/s, 470 m/s**

8. A baseball pitcher brings his arm forward during a pitch, rotating the forearm about the elbow. If the velocity of the ball in the pitcher's hand is 35.0 m/s and the ball is 0.300 m from the elbow joint, what is the angular velocity of the forearm? (OpenStax 6.5) **117 rad/s**

9. In lacrosse, a ball is thrown from a net on the end of a stick by rotating the stick and forearm about the elbow. If the angular velocity of the ball about the elbow joint is 30.0 rad/s and the ball is 1.30 m from the elbow joint, what is the velocity of the ball? (OpenStax 6.6) **39.0 m/s**

10. A car travels at a constant speed around a circular track whose radius is 2.6 km. The car goes once around the track in 360 s. What is the magnitude of the centripetal acceleration of the car? (Cutnell 5.2) **0.79 m/s²**

11. Computer-controlled display screens provide drivers in the Indianapolis 500 with a variety of information about how their cars are performing. For instance, as a car is going through a turn, a speed of 221 mi/h (98.8 m/s) and a centripetal acceleration of 3.00g (three times the acceleration due to gravity) are displayed. Determine the radius of the turn (in meters). (Cutnell 5.5) **332 m**

12. There is a clever kitchen gadget for drying lettuce leaves after you wash them. It consists of a cylindrical container mounted so that it can be rotated about its axis by turning a hand crank. The outer wall of the cylinder is perforated with small holes. You put the wet leaves in the container and turn the crank to spin off the water. The radius of the container is 12 cm. When the cylinder is rotating at 2.0 rev/s, what is the magnitude of the centripetal acceleration at the outer wall. (Cutnell 5.6) **19 m/s²**

13. Each of the space shuttle's main engines is fed liquid hydrogen by a high-pressure pump. Turbine blades inside the pump rotate at 617 rev/s. A point on one of the blades traces out a circle with a radius of 0.020 m as the blade rotates. (a) What is the magnitude of the centripetal acceleration that the blade must sustain at this point? (b) Express this acceleration as a multiple of g. (Cutnell 5.8) **3.0×10^5 m/s², 3.1×10^4 g**

14. A fairground ride spins its occupants inside a flying saucer-shaped container. If the horizontal circular path the riders follow has an 8.00 m radius, at how many revolutions per minute will the riders be subjected to a centripetal acceleration 1.50 times that due to gravity? (OpenStax 6.10) **12.9 rev/min**

15. The propeller of a World War II fighter plane is 2.30 m in diameter. (a) What is its angular velocity in radians per second if it spins at 1200 rev/min? (b) What is the linear speed of its tip at this angular velocity if the plane is stationary on the tarmac? (c) What is the centripetal acceleration of the propeller tip under these conditions? Calculate it in meters per second squared and convert to multiples of g. (OpenStax 6.13) **126 rad/s, 145 m/s, 1.82×10^4 m/s, 1.85×10^3 g**

16. Olympic ice skaters are able to spin at about 5 rev/s. (a) What is their angular velocity in radians per second? (b) What is the centripetal acceleration of the skater's nose if it is 0.120 m from the axis of rotation? (c) An exceptional skater named Dick Button was able to spin much faster in the 1950s than anyone since—at about 9 rev/s. What was the centripetal acceleration of the tip of his nose, assuming it is at 0.120 m radius? (d) Comment on the magnitudes of the accelerations found. It is reputed that Button ruptured small blood vessels during his spins. (OpenStax 6.16) **31.4 rad/s, 118 m/s², 384 m/s²**

17. A rotating space station is said to create "artificial gravity"—a loosely-defined term used for an acceleration that would be crudely similar to gravity. The outer wall of the rotating space station would become a floor for the astronauts, and centripetal acceleration supplied by the floor would allow astronauts to exercise and maintain muscle and bone strength more naturally than in non-rotating space environments. If the space station is 200 m in diameter, what angular velocity would produce an "artificial gravity" of 9.80m/s² at the rim? (OpenStax 6.19) **0.313 rad/s**