PHYS11 CH:6.1-6.2

Circular & Rotational Motion

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Learning Objectives

By the end of this lesson, you will be able to:

- Define and calculate angle of rotation and angular velocity
- Understand uniform circular motion
- Calculate centripetal acceleration and force
- Solve problems involving circular motion

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Key Terms & Definitions

- **Angle of Rotation** ($\Delta\theta$): Angular displacement measured in radians
- **Arc Length** (Δs): Distance traveled along circular path
- **Radius of Curvature** (r): Radius of circular path

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Key Terms & Definitions

- **Angular Velocity** (ω): Rate of change of angle with time

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Key Terms & Definitions

- **Centripetal Acceleration** (a_c): Acceleration toward center of circle
- **Centripetal Force** (F_c): Force causing circular motion

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What is the centrifugal "force"?

- Not a real force!
- Appears in rotating reference frames
- Feels like you're being "thrown outward"

The Fictitious Centrifugal Force

What is the centrifugal "force"?

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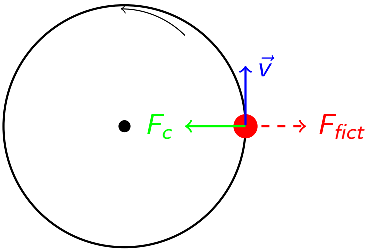
Examples in daily life:

- Car turning a corner
- Tea leaves gathering in center of cup
- Clothes in a washing machine



Remember:

- Objects want to travel in straight lines (Newton's 1st Law)
- What we feel as "outward force" is actually inertia
- Real force is centripetal (inward), causing circular motion

https://en.wikipedia.org/wiki/Centrifugal_force

Important Equations

Angle of Rotation: $\Delta\theta = \dfrac{\Delta s}{r}$

Angular Velocity: $\omega = \dfrac{\Delta\theta}{\Delta t}$

Tangential Velocity: $v = r\omega$

Centripetal Acceleration: $a_c = \dfrac{v^2}{r} = r\omega^2$

Centripetal Force: $F_c = \dfrac{mv^2}{r} = mr\omega^2$

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I Do - Example

A car drives around a circular track of radius 100 m at a constant speed of 20 m/s.

1. Calculate the centripetal acceleration
2. Find the centripetal force if the car's mass is 1500 kg

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Solution:

$$a_c = \frac{v^2}{r} = \frac{(20 \text{ m/s})^2}{100 \text{ m}} = 4 \text{ m/s}^2$$

$$F_c = ma_c = (1500 \text{ kg})(4 \text{ m/s}^2) = 6000 \text{ N}$$

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We Do - Together

Let's solve this together: A CD spins at 300 rpm (revolutions per minute).

1. Convert rpm to angular velocity in rad/s
2. Calculate the tangential velocity at r $=$ 6 cm

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Step 1: Convert rpm to rad/s

$$\omega = 300 \text{ rev/min} \times \frac{2\pi \text{ rad}}{1 \text{ rev}} \times \frac{1 \text{ min}}{60 \text{ s}} = 31.4 \text{ rad/s}$$

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Step 2: Calculate tangential velocity

$$v = r\omega = (0.06 \text{ m})(31.4 \text{ rad/s}) = 1.88 \text{ m/s}$$

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You Do - Practice Problem

A ball attached to a string is swung in a horizontal circle with radius 0.5 m. If the ball makes one complete revolution in 1.2 seconds:

1. Calculate the angular velocity
2. Find the centripetal acceleration
3. Determine the tension in the string if the ball's mass is 0.2 kg

You Do - Solution

1. Angular velocity:

$$\omega = \frac{2\pi}{T} = \frac{2\pi \text{ rad}}{1.2 \text{ s}} = 5.24 \text{ rad/s}$$

2. Centripetal acceleration:

$$a_c = r\omega^2 = (0.5 \text{ m})(5.24 \text{ rad/s})^2 = 13.7 \text{ m/s}^2$$

3. Tension (centripetal force):

$$F_c = ma_c = (0.2 \text{ kg})(13.7 \text{ m/s}^2) = 2.74 \text{ N}$$

Summary

Key takeaways:

- Circular motion requires centripetal force
- a_c and F_c always point toward center
- Angular quantities can be converted to linear quantities using radius
- Uniform circular motion means constant speed but changing velocity direction