PHYS11 CH6: Uniform Circular Motion

Sections 6.1-6.4: Rotational Motion and Forces

Mr. Gullo

Physics Department

February, 2025

Learning Objectives

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

- Define and calculate rotation angle and angular velocity
- Explain centripetal acceleration and its properties
- Analyze forces in circular motion
- Understand non-inertial frames and fictitious forces

Rotation Angle

Definition

The rotation angle $\Delta\theta$ is defined as:

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

where:

- Δs = arc length
- r = radius of curvature

- Measured in radians (rad)
- One complete revolution: 2π rad $= 360^\circ$

CH6/phys12-mechanics-circular-motion-arc.png

Angular Velocity

Definition

Angular velocity ω is the rate of change of angle:

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

Relationship to Linear Velocity

$$v = r\omega$$

where:

- v = linear velocity
- r = radius
- ω = angular velocity

CH6/phys12-mechanics-angular-velocity-wheel.png

Media

- Centripetal Acceleration
- https://www.youtube.com/watch?v=90rFibLktF4
- Application
- https://youtu.be/im-JM0f$_J$7s?si = VO4FyEuT5SLf7Fzr

Centripetal Acceleration

Definition

Centripetal acceleration is the acceleration toward the center of circular motion:

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

- Always points toward center of circle
- Magnitude depends on speed and radius
- Required for circular motion

CH6/phys12-mechanics-centripetal-acceleration.png

Example: Centripetal Acceleration

I Do: Car on Curved Path

A car travels around a curve of radius 100 m at 20 m/s. Calculate the centripetal acceleration.

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

Media

- Centripetal Force
- https://www.youtube.com/watch?v=4bMawIIWi7w

Centripetal Force

Definition

The centripetal force required for circular motion is:

$$F_c = ma_c = m\frac{v^2}{r} = mr\omega^2$$

- Net force must point toward center
- Can be provided by various forces:
  - Tension
  - Gravity
  - Friction
  - Normal force

CH6/phys12-mechanics-centripetal-force-diagram.png

We Do: Centripetal Force Problem

Problem

A 1000 kg car travels at 15 m/s around a curve of radius 50 m. What centripetal force is required?

$$\begin{aligned} F_c &= m\frac{v^2}{r} \\ &= (1000\text{ kg})\frac{(15\text{ m/s})^2}{50\text{ m}} \\ &= 4500\text{ N} \end{aligned}$$

Fictitious Forces

Key Points

- Appear in non-inertial (accelerating) frames
- Not "real" forces - arise from acceleration of reference frame
- Examples:
  - Centrifugal force
  - Coriolis force

Media

- Centrifugal force
- https://www.youtube.com/watch?v=gRVIWWJwzfY

Media

- Coriolis force
- https://www.youtube.com/watch?v=rdGtcZSFRLk

The Coriolis Effect

Properties

- Appears in rotating reference frames
- Affects motion on rotating Earth
- Causes deflection of:
  - Weather systems
  - Projectiles
  - Ocean currents

You Do: Practice Problem

Problem

A 0.5 kg ball is attached to a string and swung in a horizontal circle of radius 1.5 m. If the ball makes one complete revolution in 2 seconds:

1. Calculate the angular velocity
2. Find the centripetal acceleration
3. Determine the tension in the string

Summary

Key Concepts

- Angular quantities describe rotational motion
- Centripetal acceleration points to center
- Centripetal force causes circular motion
- Fictitious forces appear in non-inertial frames