

# PHYS11 CH:5.4

## Static and Kinetic Friction

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# Table of Contents

- 1 Introduction to Friction
- 2 Inclined Planes
- 3 Example Problems
- 4 Check Your Understanding

# Types of Friction

- **Friction:** Force that opposes motion
- Two main types:
  - **Static Friction:** Acts on objects at rest
  - **Kinetic Friction:** Acts on objects in motion
- Maximum static friction is usually greater than kinetic friction

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# Friction Formulas

## Static Friction

$$f_s \leq \mu_s N$$

where:

- $f_s$  is static friction force
- $\mu_s$  is coefficient of static friction
- $N$  is normal force

## Kinetic Friction

$$f_k = \mu_k N$$

where:

- $f_k$  is kinetic friction force
- $\mu_k$  is coefficient of kinetic friction

# Coefficients of Friction

System	Static Friction	Kinetic Friction
Rubber on dry concrete	1.0	0.7
Wood on wood	0.5	0.3
Steel on steel (dry)	0.6	0.3
Steel on steel (oiled)	0.05	0.03
Ice on ice	0.1	0.03

# Table of Contents

- 1 Introduction to Friction
- 2 Inclined Planes
- 3 Example Problems
- 4 Check Your Understanding

# Forces on an Inclined Plane

- Weight components on an incline:
  - Parallel to slope:  $w_{\parallel} = mg \sin \theta$
  - Perpendicular to slope:  $w_{\perp} = mg \cos \theta$
- Normal force ( $N$ ) equals perpendicular component
- Friction acts parallel to surface, opposing motion

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# Problem Solving Steps

1. Draw a sketch of the problem
2. Identify known and unknown quantities
3. Draw free-body diagram with rotated coordinate system
4. Apply Newton's second law:
  - If no acceleration:  $F_{net} = 0$
  - If accelerating:  $F_{net} = ma$
5. Check answer for reasonableness



# Table of Contents

- 1 Introduction to Friction
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- 3 Example Problems**
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# Example: Skier on a Slope

## Problem

A 62 kg skier slides down a snowy slope at  $25^\circ$ . Find  $\mu_k$  if friction is 45.0 N.

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## Solution

$$N = mg \cos \theta = (62 \text{ kg})(9.80 \text{ m/s}^2) \cos(25)$$

$$f_k = \mu_k N = 45.0 \text{ N}$$

$$\mu_k = \frac{f_k}{N} = \frac{45.0 \text{ N}}{551 \text{ N}} = 0.082$$

# Example: Acceleration on an Incline

## Problem - Part A

What is the skier's acceleration if friction is negligible?

## Solution

$$a = g \sin \theta$$

$$a = (9.80 \text{ m/s}^2) \sin(25) = 4.14 \text{ m/s}^2$$

## Example: Acceleration with Friction

### Problem - Part B

What is the skier's acceleration with 45.0 N friction?

### Solution

$$F_{net} = mg \sin \theta - f_k$$

$$a = g \sin \theta - \frac{f_k}{m}$$

$$a = 9.80 \sin(25) - \frac{45.0}{60.0} = 3.39 \text{ m/s}^2$$

# Table of Contents

- 1 Introduction to Friction
- 2 Inclined Planes
- 3 Example Problems
- 4 Check Your Understanding

# Review Questions

- ① What is friction?
  - An external force that opposes relative motion
- ② Compare static vs. kinetic friction:
  - Static: Acts on objects at rest
  - Kinetic: Acts on objects in motion
  - Static friction maximum  $>$  Kinetic friction





- Static friction maximum  $>$  Kinetic friction

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