PHYS11 CH:5.4

Static and Kinetic Friction

Mr. Gullo

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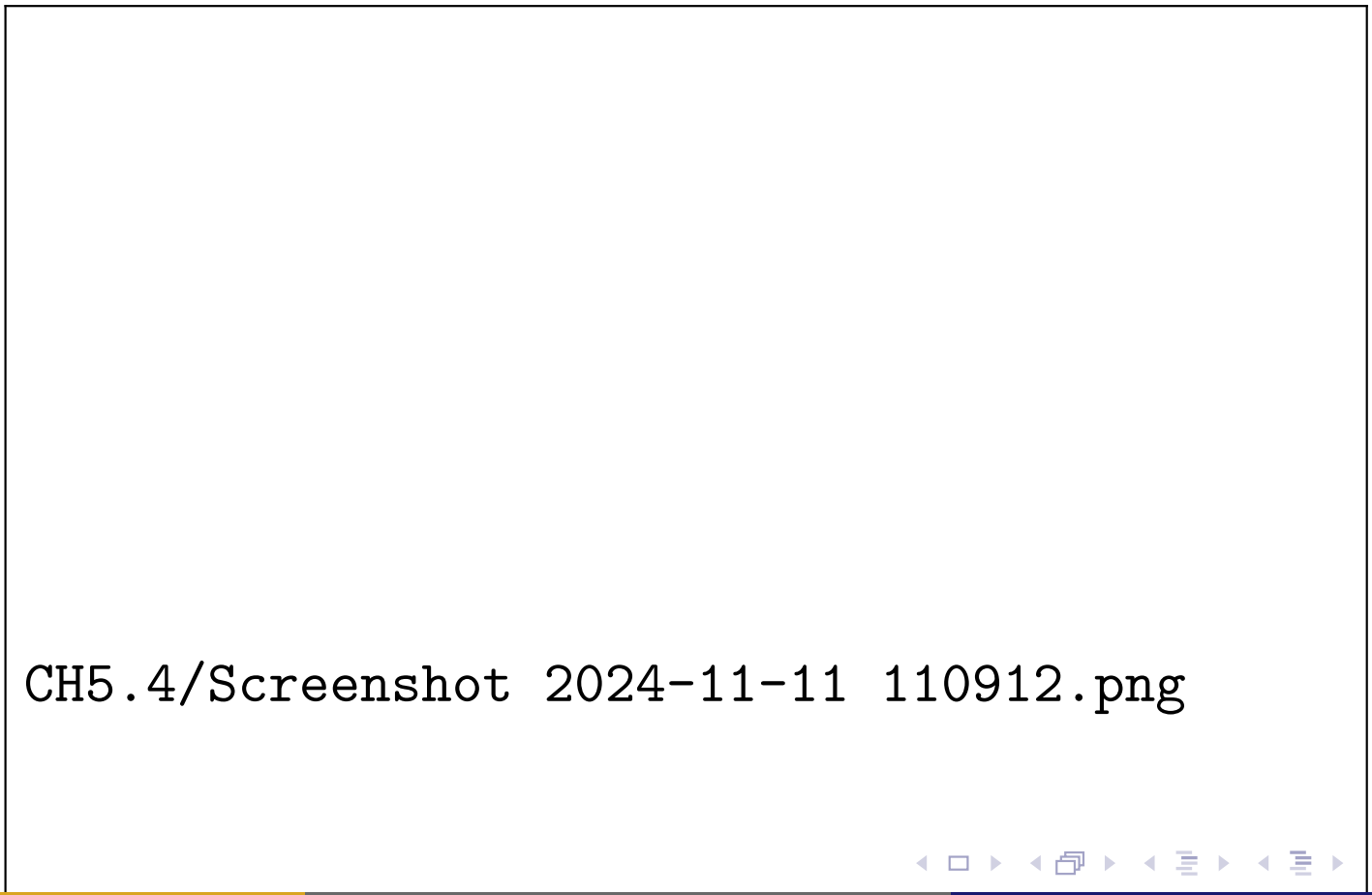
Types of Friction

- **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



Friction Formulas

Static Friction

$$f_s \leq \mu_s N$$

where:

- f_s is static friction force
- μ_s is coefficient of static friction
- N is normal force

Kinetic Friction

$$f_k = \mu_k N$$

where:

- f_k is kinetic friction force
- μ_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

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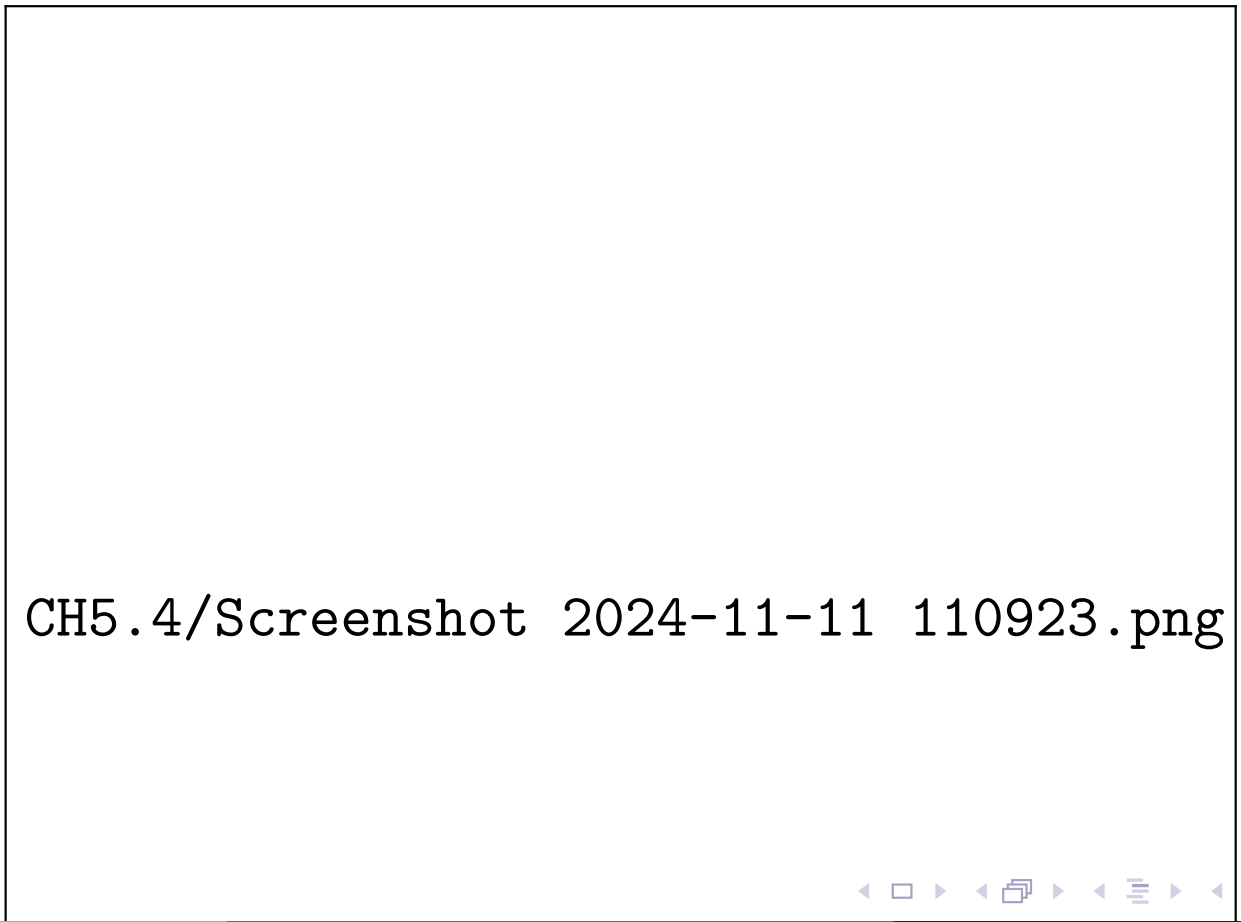
Forces on an Inclined Plane

- 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



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

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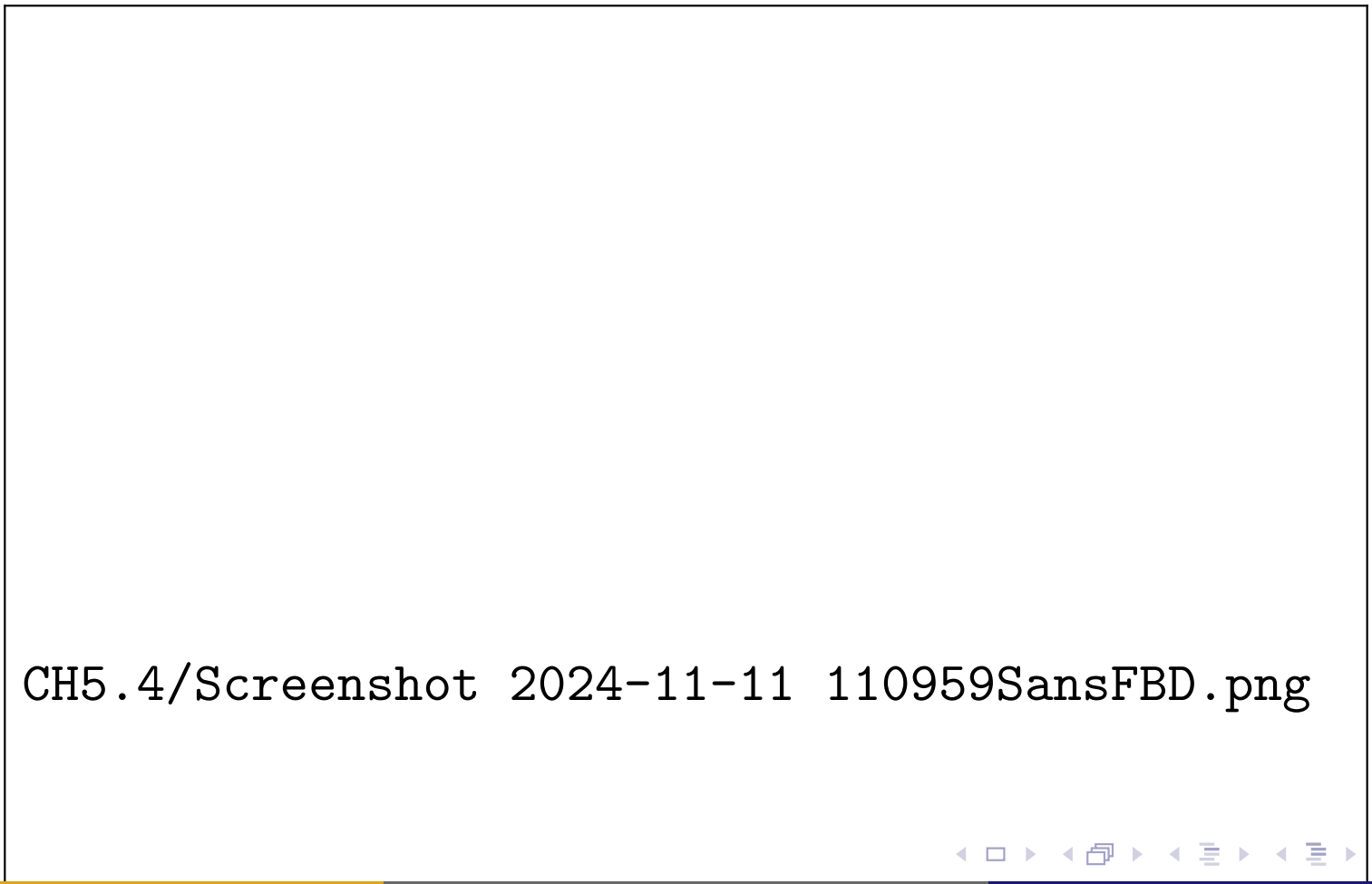
Example: Skier on a Slope

Problem

A 62 kg skier slides down a snowy slope at 25°. Find μ_k if friction is 45.0 N.



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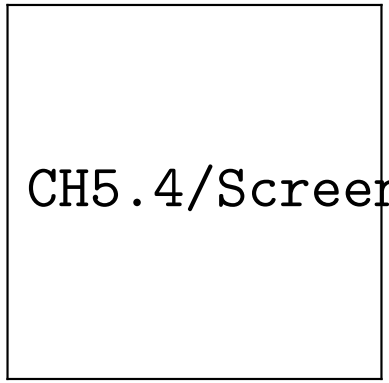

Solution

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

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

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

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

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

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

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

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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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