

You can draw here

# Physics 111 - Class 7C

## Force Applications III

October 22, 2021

Do not draw in/on this box!

You can draw here

You can draw here

# Class Outline

- Logistics / Announcements
- Mid-course Feedback Results
- Test 2 Reflection
- Introduction to Chapter 6
- Activity: Worked Problems
- HW6.8 - Two triangle blocks

# Logistics/Announcements

- Lab this week: Lab 4
- HW6 due this week on Thursday at 6 PM
- Learning Log 6 due on Saturday at 6 PM
- HW and LL deadlines have a 48 hour grace period
- Test/Bonus Test: Bonus Test 2 available this week (Chapters 3 & 4)
- Test Window: Friday 6 PM - Sunday 6 PM



## Physics 111

Search this book...

Unsyllabus

### ABOUT THIS COURSE

- Course Syllabus (Official)
- Course Schedule
- Accommodations
- How to do well in this course

### GETTING STARTED

- Before the Term starts
- After the first class
- In the first week
- Week 1 - Introductions!

### PART 1 - KINEMATICS

- Week 2 - Chapter 2
- Week 3 - Chapter 3
- Week 4 - Chapter 4

### PART 2 - DYNAMICS

- Week 5 - Chapter 5
- Week 6 - Week Off !!

### Week 7 - Chapter 6

Readings

**Videos**

Homework

Tutorial

## Friction

Friction: Crash Course Physics #6

Copy link

6

FRICITION

Watch on YouTube

- Video 2
- Video 3
- Video 4
- Video 5
- Video 6
- Video 7
- Video 8
- Video 9
- Video 10
- Video 11
- Video 12

## Required Videos

### 1. Introduction to Equilibrium

Introduction to Equilibrium

Copy link

$\vec{F}_N$

$\vec{F}_f$

$\vec{F}_a$

## Preface

## ▼ Mechanics

- ▶ 1 Units and Measurement
- ▶ 2 Vectors
- ▶ 3 Motion Along a Straight Line
- ▶ 4 Motion in Two and Three Dimensions
- ▶ 5 Newton's Laws of Motion
- ▶ 6 Applications of Newton's Laws
  - Introduction**
    - 6.1 Solving Problems with Newton's Laws
    - 6.2 Friction
    - 6.3 Centripetal Force
    - 6.4 Drag Force and Terminal Speed
  - ▶ Chapter Review
- ▶ 7 Work and Kinetic Energy
- ▶ 8 Potential Energy and Conservation of Energy
- ▶ 9 Linear Momentum and Collisions
- ▶ 10 Fixed-Axis Rotation
- ▶ 11 Angular Momentum
- ▶ 12 Static Equilibrium and Elasticity



**Figure 6.1** Stock cars racing in the Grand National Divisional race at Iowa Speedway in May, 2015. Cars often reach speeds of 200 mph (320 km/h).  
(credit: modification of work by Erik Schneider/U.S. Navy)

## Chapter Outline

- [6.1 Solving Problems with Newton's Laws](#)
- [6.2 Friction](#)
- [6.3 Centripetal Force](#)
- [6.4 Drag Force and Terminal Speed](#)

Car racing has grown in popularity in recent years. As each car moves in a curved path around the turn, its wheels also spin rapidly. The wheels complete many revolutions while the car makes only part of one (a circular arc). How

## Preface

## ▼ Mechanics

- ▶ 1 Units and Measurement
- ▶ 2 Vectors
- ▶ 3 Motion Along a Straight Line
- ▶ 4 Motion in Two and Three Dimensions
- ▶ 5 Newton's Laws of Motion
- ▶ 6 Applications of Newton's Laws

**Introduction**

Mon      6.1 Solving Problems with Newton's Laws

Wed      6.2 Friction

6.3 Centripetal Force

Fri      6.4 Drag Force and Terminal Speed

## ▶ Chapter Review

- ▶ 7 Work and Kinetic Energy
- ▶ 8 Potential Energy and Conservation of Energy
- ▶ 9 Linear Momentum and Collisions
- ▶ 10 Fixed-Axis Rotation
- ▶ 11 Angular Momentum
- ▶ 12 Static Equilibrium and Elasticity



**Figure 6.1** Stock cars racing in the Grand National Divisional race at Iowa Speedway in May, 2015. Cars often reach speeds of 200 mph (320 km/h).  
(credit: modification of work by Erik Schneider/U.S. Navy)

## Chapter Outline

[6.1 Solving Problems with Newton's Laws](#)

[6.2 Friction](#)

[6.3 Centripetal Force](#)

[6.4 Drag Force and Terminal Speed](#)

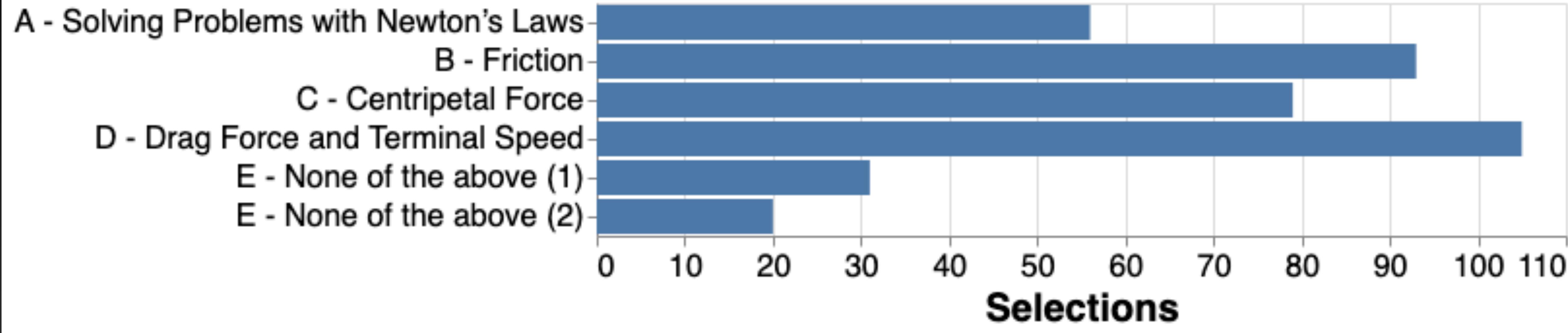
Car racing has grown in popularity in recent years. As each car moves in a curved path around the turn, its wheels also spin rapidly. The wheels complete many revolutions while the car makes only part of one (a circular arc). How

# **Friday's Class**

**6.4 Drag force and Terminal Speed**

# HW 6 Reflection

**Week 6 - Most Confusing Concepts**  
**N = 192 Students**



Most confusing things:

Friction

Drag Force

Centripetal Force

HW 6.8!!

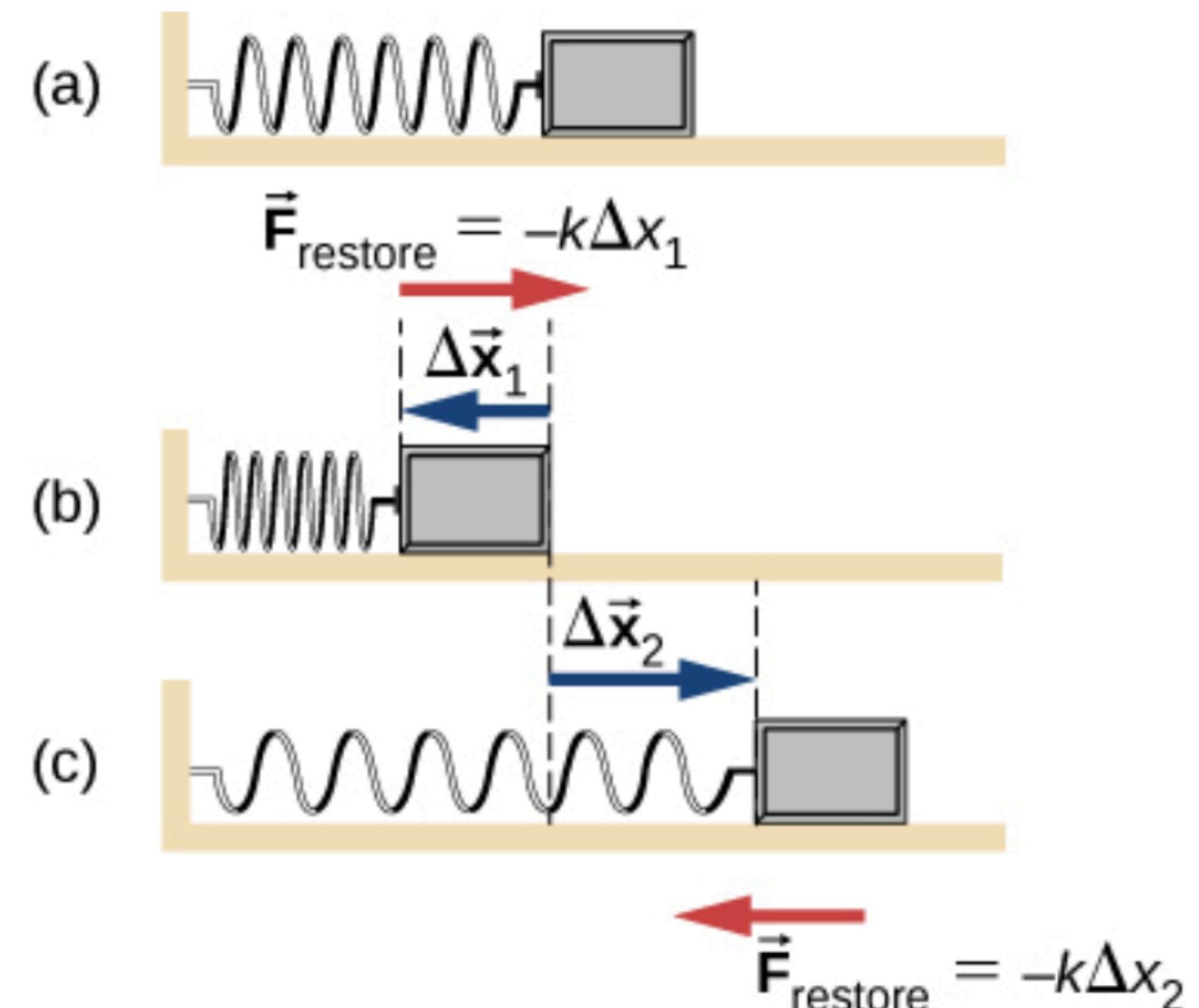
Springs

## Spring force

A spring is a special medium with a specific atomic structure that has the ability to restore its shape, if deformed. To restore its shape, a spring exerts a restoring force that is proportional to and in the opposite direction in which it is stretched or compressed. This is the statement of a law known as Hooke's law, which has the mathematical form

$$\vec{F} = -k\vec{x}.$$

The constant of proportionality  $k$  is a measure of the spring's stiffness. The line of action of this force is parallel to the spring axis, and the sense of the force is in the opposite direction of the displacement vector ([Figure 5.29](#)). The displacement must be measured from the relaxed position;  $x = 0$  when the spring is relaxed.



**Figure 5.29** A spring exerts its force proportional to a displacement, whether it is compressed or stretched. (a) The spring is in a relaxed position and exerts no force on the block. (b) The spring is compressed by displacement  $\Delta\vec{x}_1$  of the object and exerts restoring force  $-k\Delta\vec{x}_1$ . (c) The spring is stretched by displacement  $\Delta\vec{x}_2$  of the object and exerts restoring force  $-k\Delta\vec{x}_2$ .

# Spring Force

# Drag Force

## DRAG FORCE

Drag force  $F_D$  is proportional to the square of the speed of the object. Mathematically,

$$F_D = \frac{1}{2} C \rho A v^2,$$

where  $C$  is the drag coefficient,  $A$  is the area of the object facing the fluid, and  $\rho$  is the density of the fluid.

# Drag Force

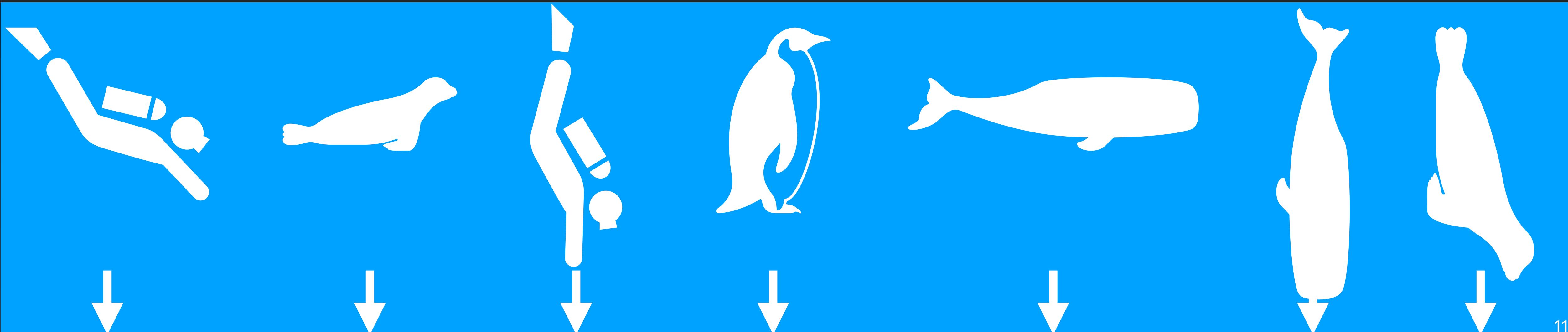
## DRAG FORCE

Drag force  $F_D$  is proportional to the square of the speed of the object. Mathematically,

$$F_D = \frac{1}{2} C \rho A v^2,$$

where  $C$  is the drag coefficient,  $A$  is the area of the object facing the fluid, and  $\rho$  is the density of the fluid.

**Rank the drag force on these specimens from highest (1) to lowest (7)**



# Terminal Velocity



# Terminal Velocity

Parachute



# Key Equations

Magnitude of static friction

$$f_s \leq \mu_s N$$

Magnitude of kinetic friction

$$f_k = \mu_k N$$

Centripetal force

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

Ideal angle of a banked curve

$$\tan \theta = \frac{v^2}{rg}$$

Drag force

$$F_D = \frac{1}{2} C \rho A v^2$$

Stokes' law

$$F_s = 6\pi r \eta v$$

# Clicker Questions

# CQ.7.9

A 2.20 kg toy plane takes off with an acceleration of  $3.30 \text{ m/s}^2$ . The engine supplies a force of 8.15 N. Determine the magnitude of drag force acting on the plane as it accelerates.

- a) 7.26 N
- b) 15.4 N
- c) 0.89 N
- d) 0.0 N

A

B

C

D

E

# CQ.7.9

A 2.20 kg toy plane takes off with an acceleration of  $3.30 \text{ m/s}^2$ . The engine supplies a force of 8.15 N. Determine the magnitude of drag force acting on the plane as it accelerates.

- a) 7.26 N
- b) 15.4 N
- c) 0.89 N
- d) 0.0 N

**Detailed solution:** Without any drag force the airplane would accelerate at  $3.7 \text{ m/s}^2$ . The drag force opposes a little bit of the force supplied by the motor. If you chose **15.4 N** you may have added a number that should have been subtracted. **7.26 N** is the net force acting on the plane. You'll need this to calculate the drag force.

A

B

C

D

E

# Activity: Worked Problems



# WP 7.3 - Rotor Ride: Friction & Centripetal Motion



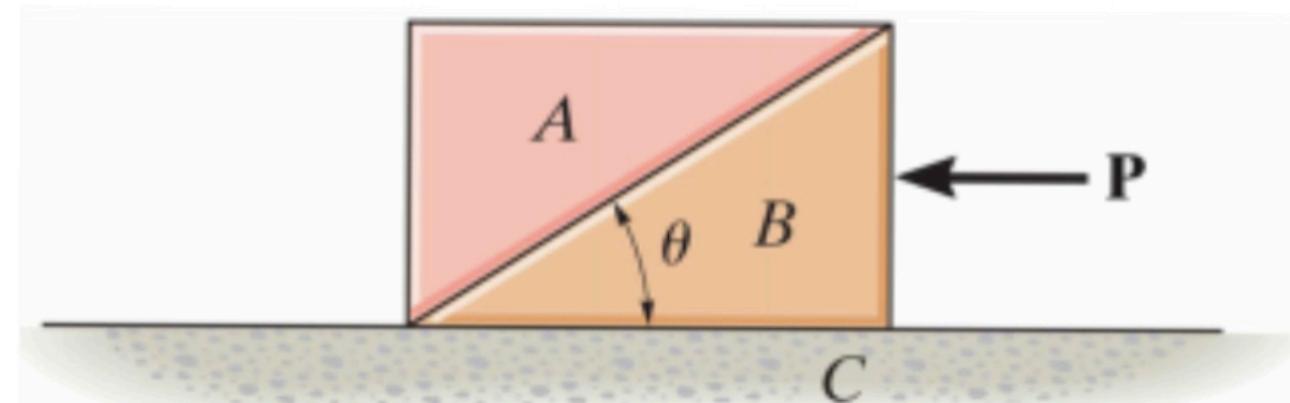
# WP 7.3 - Rotor Ride: Friction & Centripetal Motion



# HW 6.8

## HW6.8. Two Blocks Stacked

Blocks A and B each have a mass  $m = 10 \text{ kg}$ . The coefficient of static friction between A and B is  $\mu_s = 0.38$ . The angle shown is  $\theta = 33^\circ$ . Neglect any friction between B and C.



Determine the largest horizontal force  $\vec{P}$  that can be applied so that A will not slip on B.

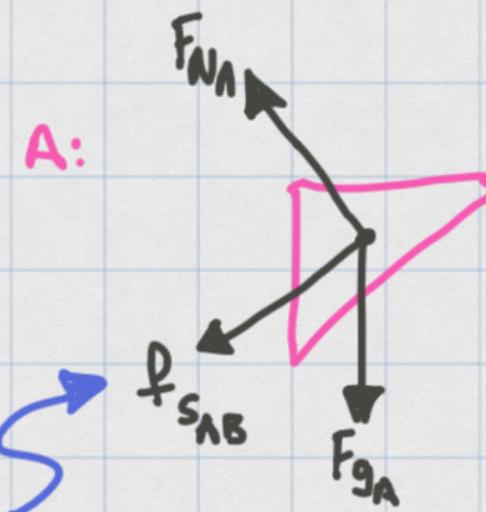
$$\vec{P} = 37.28$$

N

?

x 0%

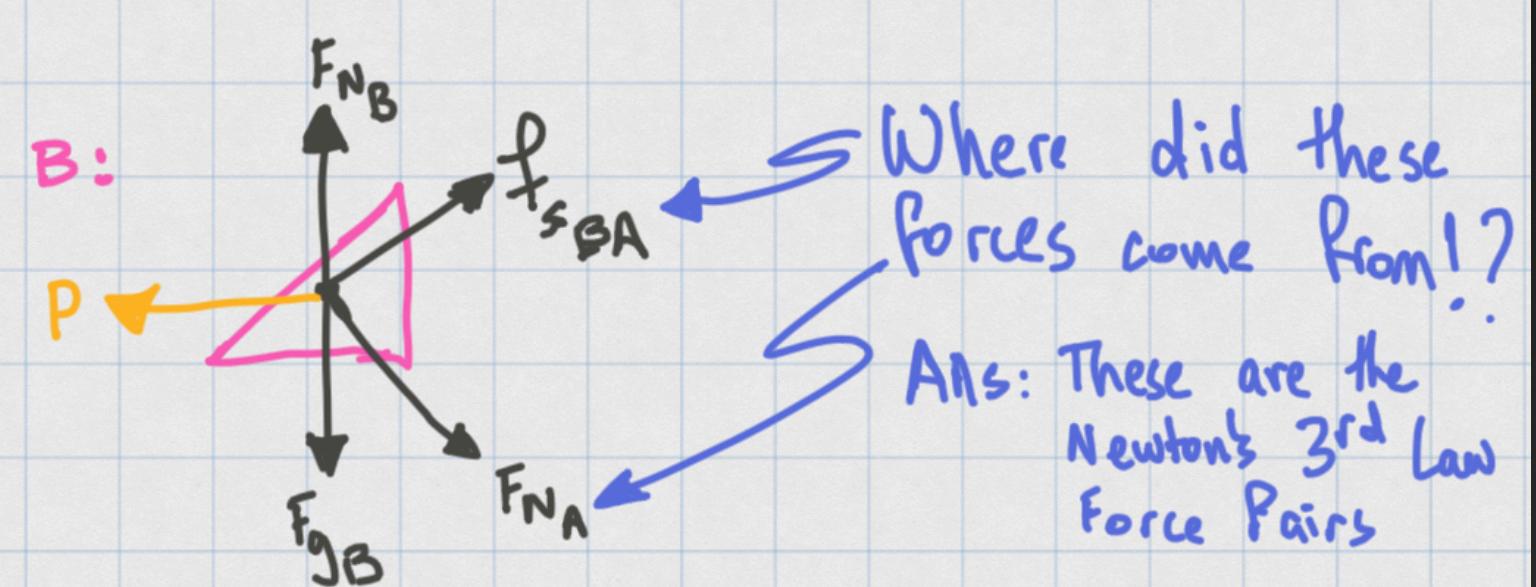
① Draw separate FBDs for each Block



Why is the  
friction in  
this direction?

If Block B is  
pushed to the  
left, Block A  
will slide up  
the ramp if

$P$  is large enough!



Where did these  
forces come from?  
Ans: These are the  
Newton's 3rd Law  
Force Pairs

Remember  $F_{NA}$  is the  
force that changes  
as  $P$  increases (or decreases)

③ Consider the case where forces  
balance such that  $a_A = a_B = a$

# HW 6.8

**See you next class!**

# Attribution

This resource was significantly adapted from the [OpenStax Instructor Slides](#) provided by Rice University. It is released under a CC-BY 4.0 license.

--- Original resource license ---

OpenStax ancillary resource is © Rice University under a CC-BY 4.0 International license; it may be reproduced or modified but must be attributed to OpenStax, Rice University and any changes must be noted.