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Physics 111 - Class 5A

Forces I

Do not draw in/on this box!

October 4, 2021

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Class Outline

- Logistics / Announcements
- Introduction to Chapter 5
- Clicker Questions
- Activity: Worked Problem

Logistics/Announcements

- Lab this week: Lab 3
- HW5 due this week on Thursday at 6 PM
- New: Finish HW5 with 100% by Wednesday 6PM and get a 10% bonus!
- Learning Log 5 due on Saturday at 6 PM
- HW and LL deadlines have a 48 hour grace period
- Test/Bonus Test: Test 2 available this week (Chapters 3 & 4)
- Test Window: Friday 6 PM - Sunday 6 PM



Physics 111

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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**
- Readings
 - Videos**
 - Homework
 - Week 5 Classes
 - Test

Content Summary from Crash Course Physics

Newton's Laws

Newton's Laws: Crash Course Physics #5

Copy link

5

Watch on YouTube

Checklist of items

- Video 1
- 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 Inertia and Inertial Mass

Introduction to Inertia and Inertial Mass

constant velocity

Copy link

Introduction

[Table of contents](#) Search this book[My highlights](#)[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

Introduction

- 5.1 Forces
- 5.2 Newton's First Law
- 5.3 Newton's Second Law
- 5.4 Mass and Weight
- 5.5 Newton's Third Law
- 5.6 Common Forces
- 5.7 Drawing Free-Body Diagrams

▶ Chapter Review

- ▶ 6 Applications of Newton's Laws
- ▶ 7 Work and Kinetic Energy
- ▶ 8 Potential Energy and Conservation of Energy
- ▶ 9 Linear Momentum and Collisions
- ▶ 10 Fixed-Axis Rotation
- ▶ 11 Angular Momentum



Figure 5.1 The Golden Gate Bridge, one of the greatest works of modern engineering, was the longest suspension bridge in the world in the year it opened, 1937. It is still among the 10 longest suspension bridges as of this writing. In designing and building a bridge, what physics must we consider? What forces act on the bridge? What forces keep the bridge from falling? How do the towers, cables, and ground interact to maintain stability?

Chapter Outline

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Introduction

[Table of contents](#) Search this book[My highlights](#)[Preface](#)

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Introduction

Mon	5.1 Forces
Wed	5.2 Newton's First Law 5.3 Newton's Second Law
Mon	5.4 Mass and Weight
Fri	5.5 Newton's Third Law 5.6 Common Forces
Mon	5.7 Drawing Free-Body Diagrams

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“Kinematics” and “Dynamics”

- For the past two weeks we have been talking about “Kinematics” in 1D, 2D, and 3D while we studied vectors...
- Kinematics help us describe the way objects move
- You were told objects had this initial velocity, or that acceleration etc...
- But how did they get those initial velocities ?
- The next two chapters are about “Dynamics” - how forces affect the motion of objects and systems.

Monday's Class

5.1 Forces

5.4 Mass and Weight

5.7 Free Body Diagrams

Units of Force

The equation $F_{\text{net}} = ma$ is used to define net force in terms of mass, length, and time. As explained earlier, the SI unit of force is the newton. Since $F_{\text{net}} = ma$,

$$1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2.$$

Although almost the entire world uses the newton for the unit of force, in the United States, the most familiar unit of force is the pound (lb), where $1 \text{ N} = 0.225 \text{ lb}$. Thus, a 225-lb person weighs 1000 N.

WEIGHT

The gravitational force on a mass is its weight. We can write this in vector form, where \vec{w} is weight and m is mass, as

$$\vec{w} = m\vec{g}.$$

5.8

In scalar form, we can write

$$w = mg.$$

5.9

Adding Forces together

Free Body Diagram

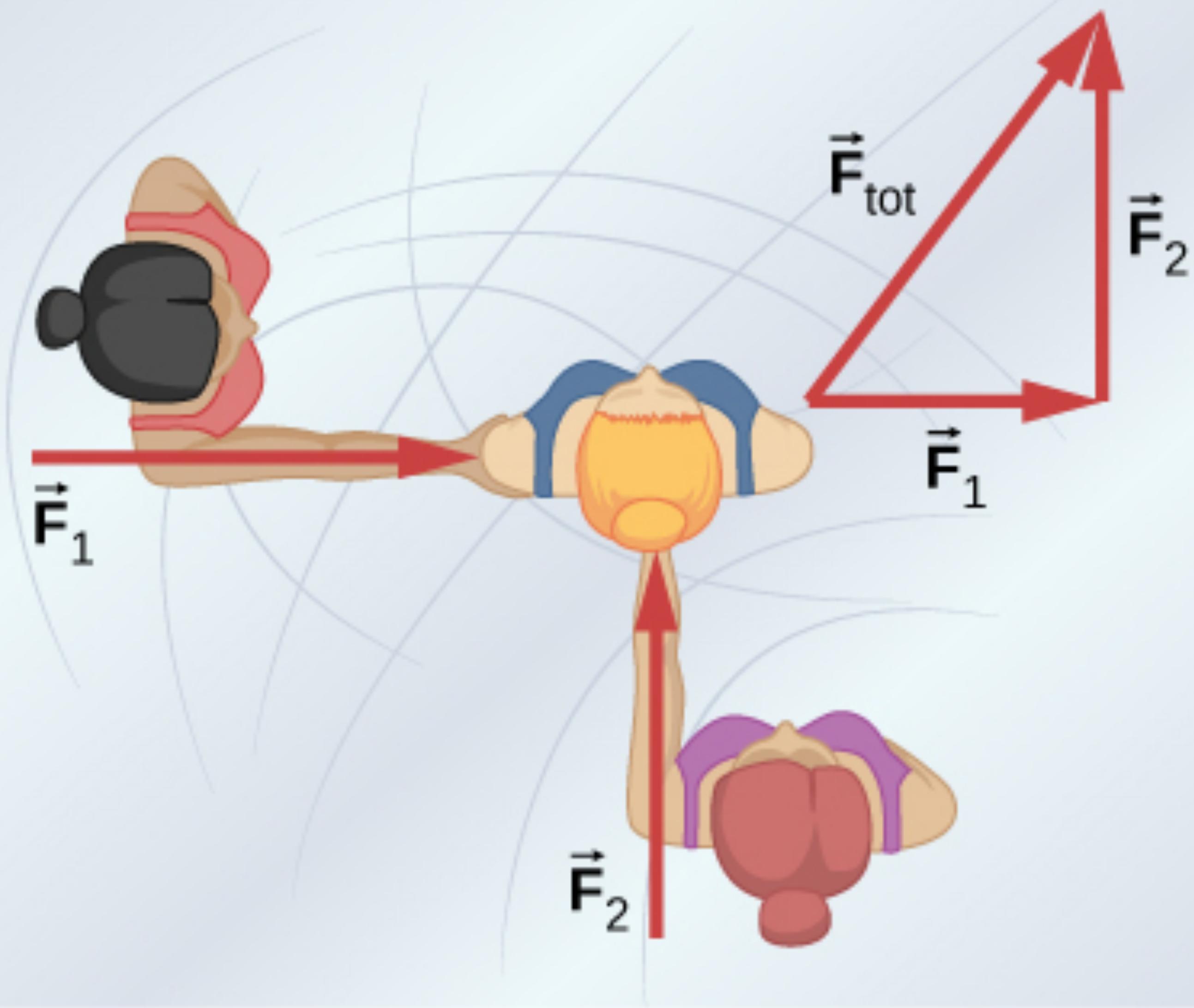


Figure 5.3

(a) An overhead view of two ice skaters pushing on a third skater. Forces are vectors and add like other vectors, so the total force on the third skater is in the direction shown.

Drawing Free Body Diagrams

Drawing Free-Body Diagrams

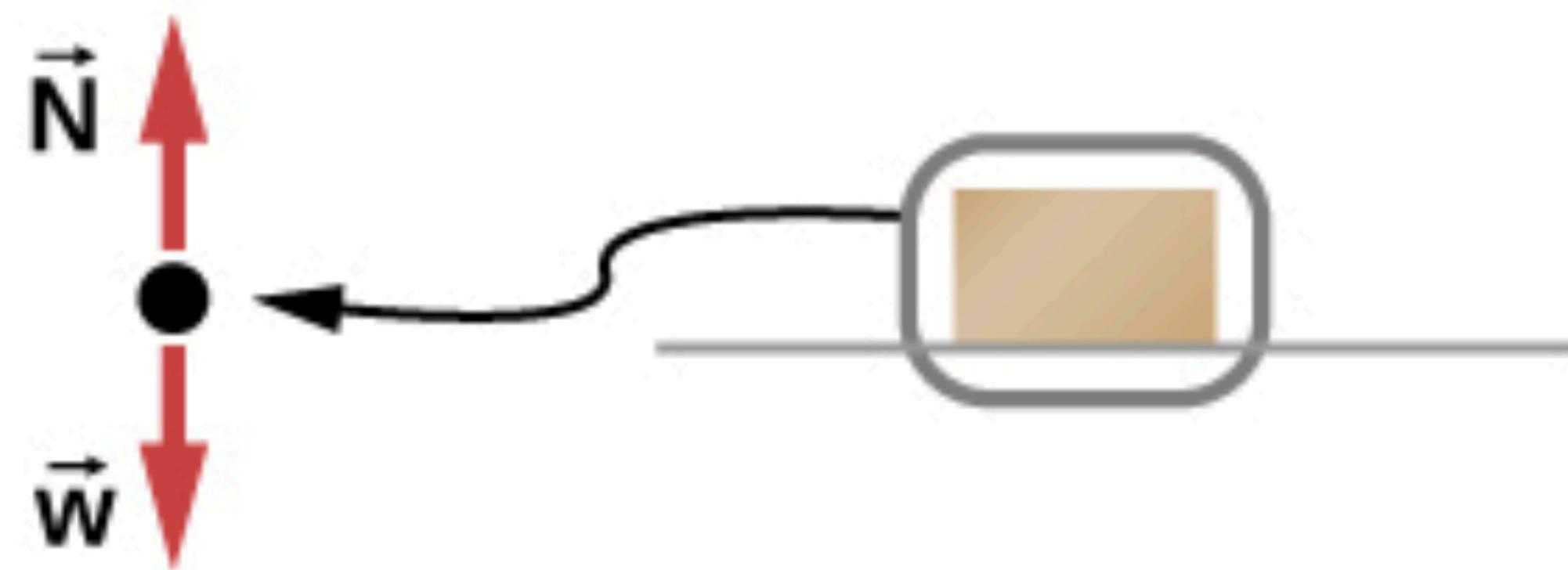
1. Draw the object under consideration. If you are treating the object as a particle, represent the object as a point. Place this point at the origin of an xy -coordinate system.
2. Include all forces that act on the object, representing these forces as vectors. However, do not include the net force on the object or the forces that the object exerts on its environment.
3. Resolve all force vectors into x - and y -components.
4. Draw a separate free-body diagram for each object in the problem.

Drawing Free Body Diagrams

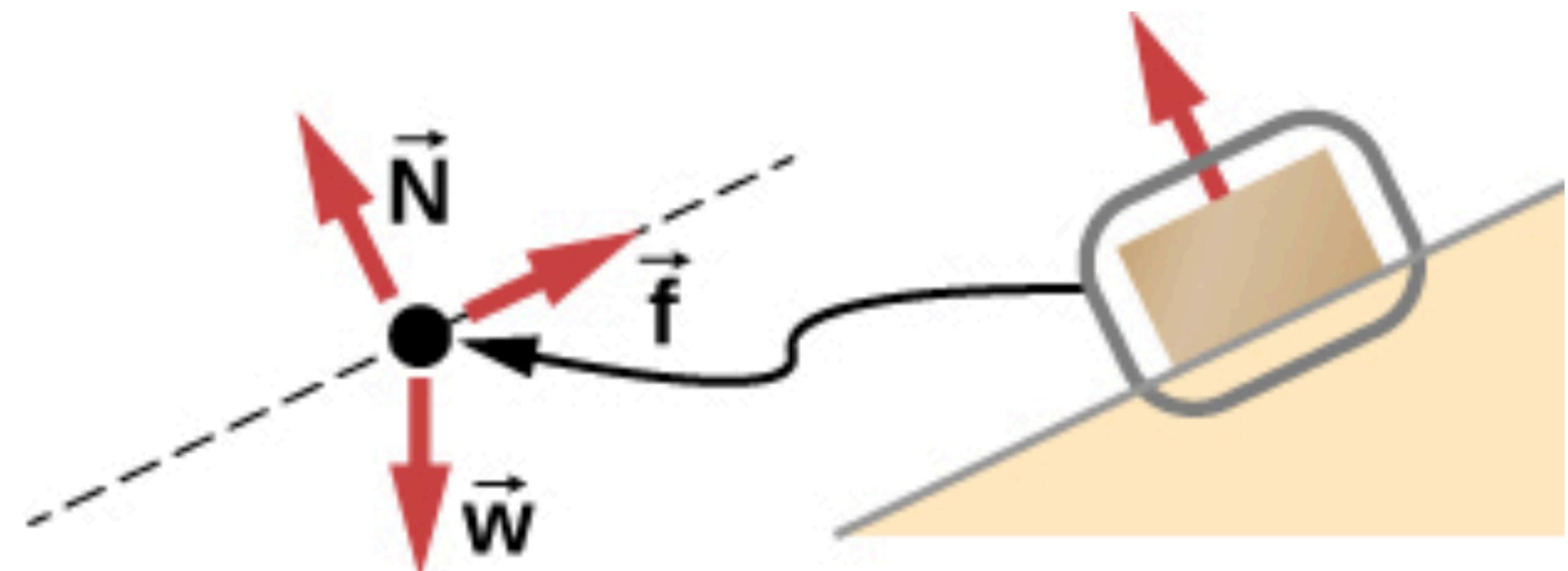
Drawing Free-Body Diagrams

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Drawing Free Body Diagrams



(a) Box at rest on a horizontal surface



(b) Box on an inclined plane

Figure 5.4 In these free-body diagrams, \vec{N} is the normal force, \vec{w} is the weight of the object, and \vec{f} is the friction.

Sled Pulled at an Angle

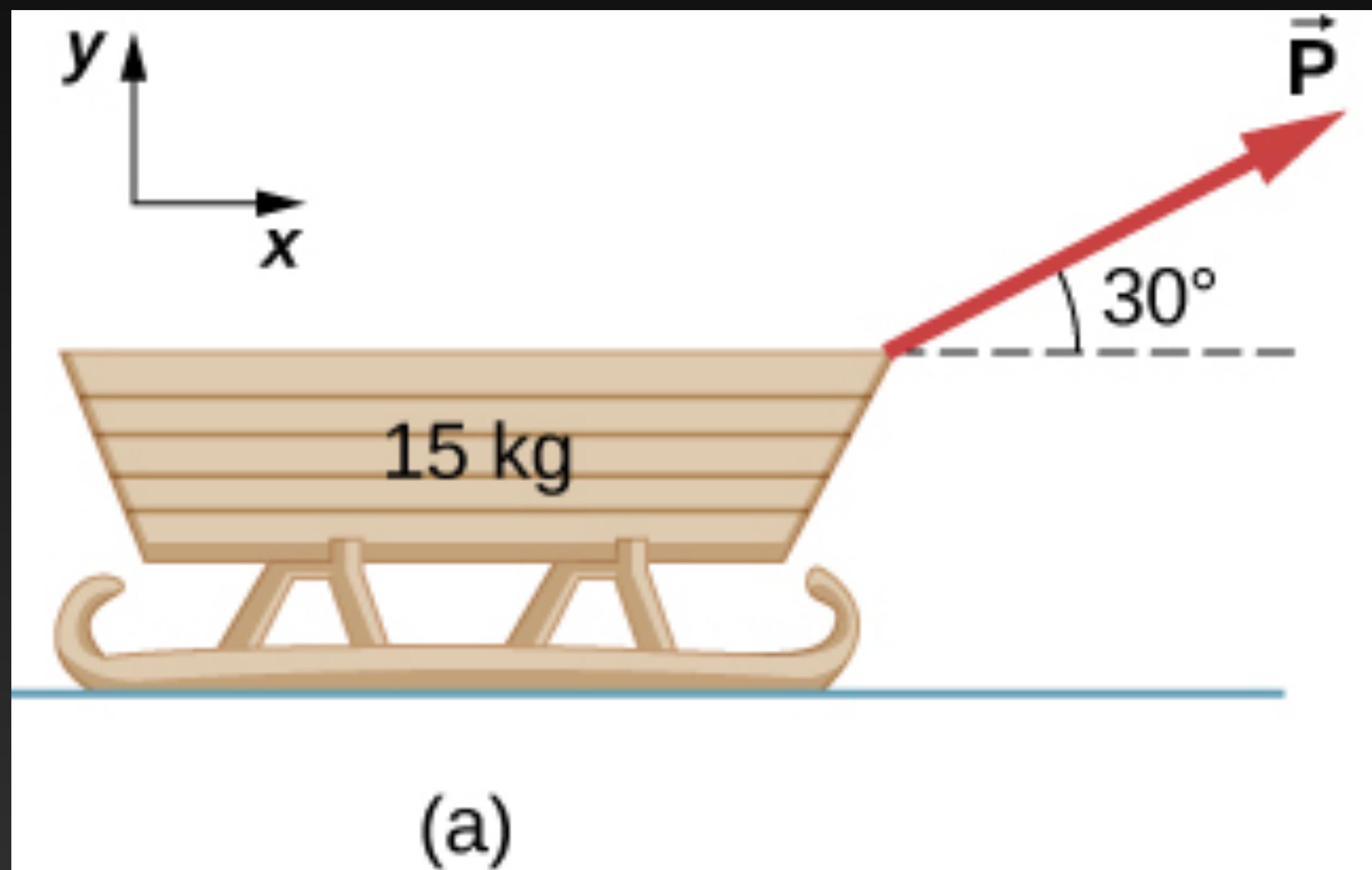


Figure 5.31

A sled is pulled by force P at an angle of 30° . Draw a Free Body Diagram of all the forces on the sled, and resolve the forces into their x and y components.

Blocks on a Ramp

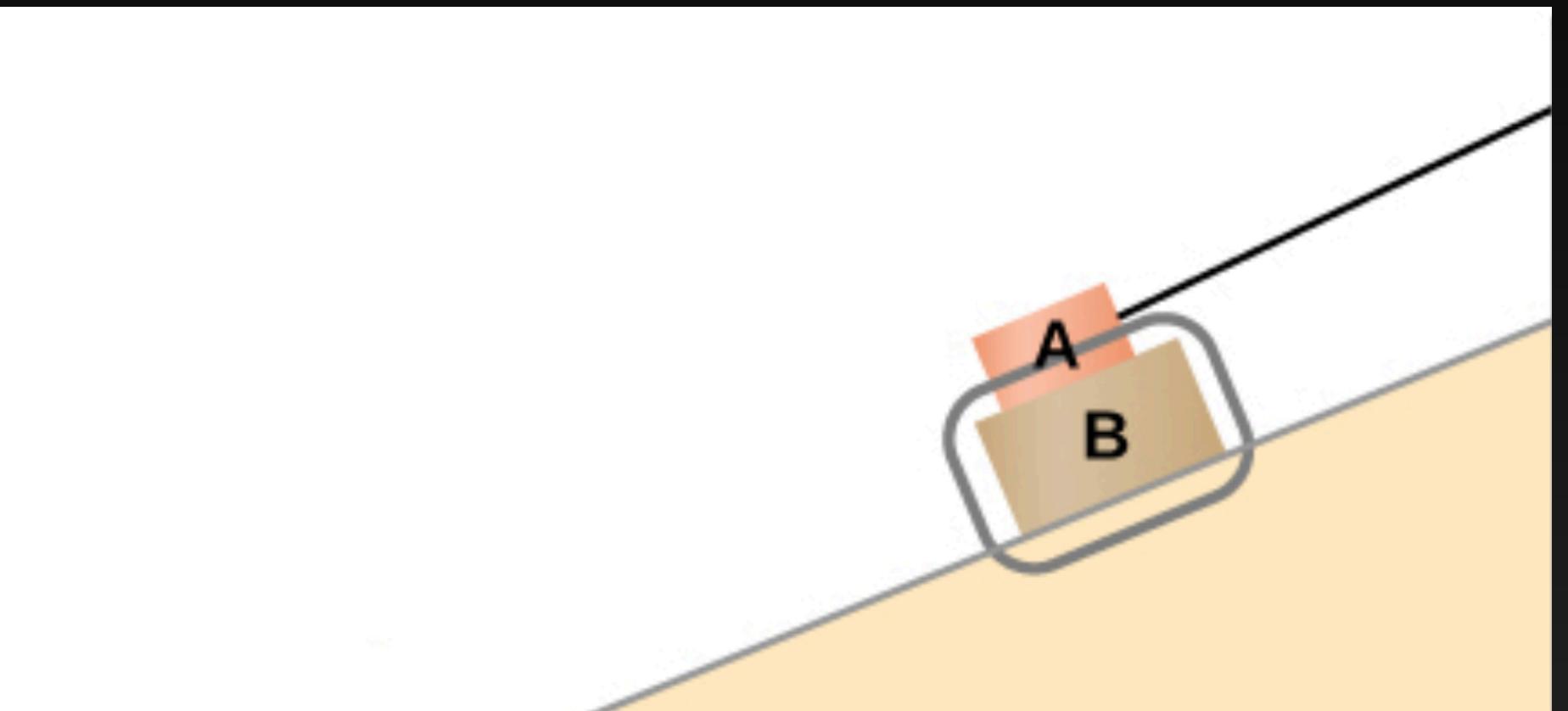
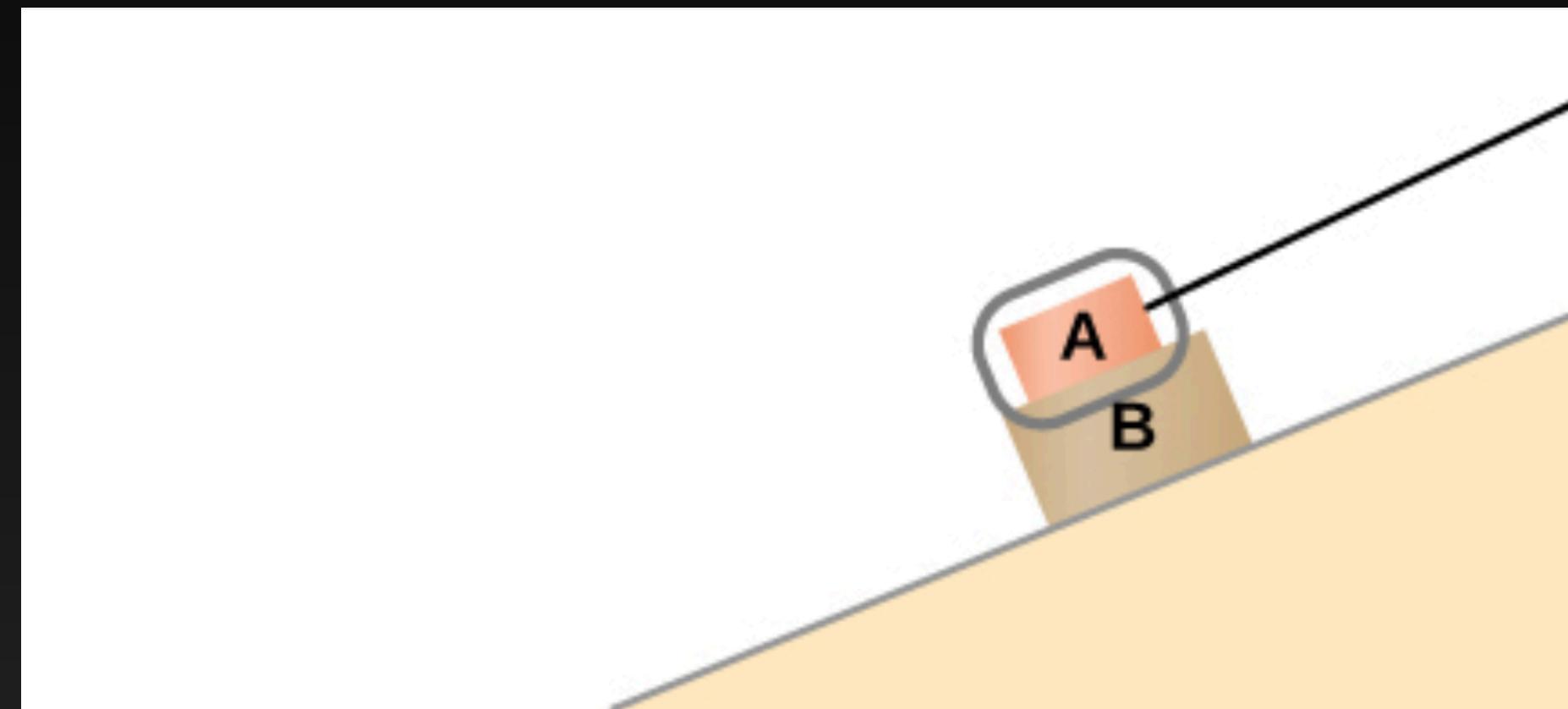
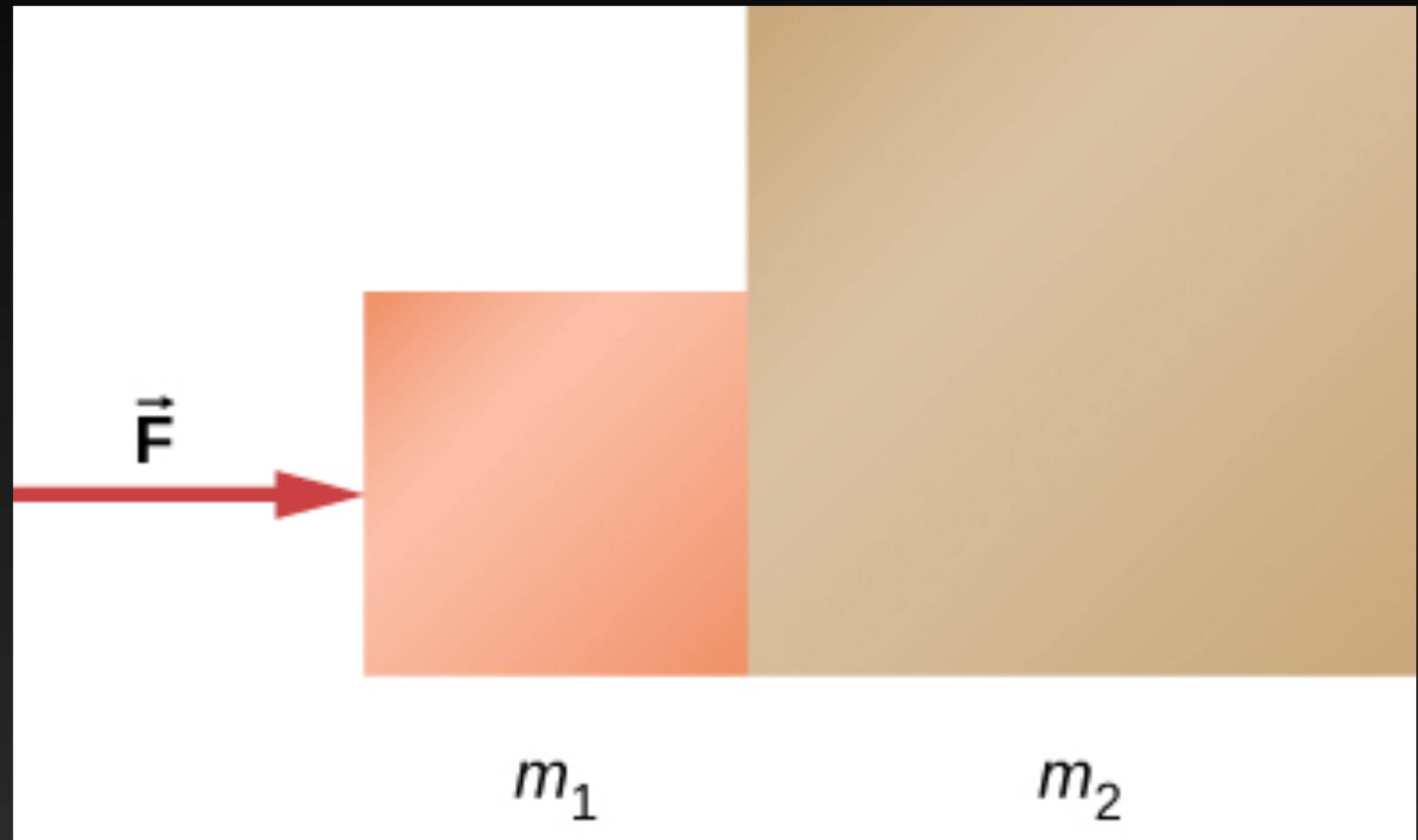


Figure 5.32

Block A is resting on top of Block B and the two blocks are placed on a ramp with an angle θ . Draw the Free Body Diagrams of both blocks, and resolve the components.

Two Blocks in Contact



Free Body Diagram

Example 5.15

Block 1 (mass m₁) is in contact with Block 2 (mass m₂) and a force F is applied to m₁, towards the right.

Draw the Free Body Diagrams on both masses.

Key Equations

Net external force

$$\vec{F}_{\text{net}} = \sum \vec{F} = \vec{F}_1 + \vec{F}_2 + \dots$$

Newton's first law

$$\vec{v} = \text{constant when } \vec{F}_{\text{net}} = \vec{0} \text{ N}$$

Newton's second law, vector form

$$\vec{F}_{\text{net}} = \sum \vec{F} = m\vec{a}$$

Newton's second law, scalar form

$$F_{\text{net}} = ma$$

Newton's second law, component form

$$\sum \vec{F}_x = m\vec{a}_x, \sum \vec{F}_y = m\vec{a}_y, \text{ and } \sum \vec{F}_z = m\vec{a}_z.$$

Newton's second law, momentum form

$$\vec{F}_{\text{net}} = \frac{d\vec{p}}{dt}$$

Definition of weight, vector form

$$\vec{w} = m\vec{g}$$

Definition of weight, scalar form

$$w = mg$$

Key Equations

Newton's third law

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

Normal force on an object resting on a horizontal surface, vector form

$$\vec{N} = -m\vec{g}$$

Normal force on an object resting on a horizontal surface, scalar form

$$N = mg$$

Normal force on an object resting on an inclined plane, scalar form

$$N = mg\cos \theta$$

Tension in a cable supporting an object of mass m at rest, scalar form

$$T = w = mg$$

Clicker Questions

CQ.4.1

An object weighs 294 N on Earth. What is its weight on the Moon?

- a) 50.1 N
- b) 30.0 N
- c) 249 N
- d) 1461 N

$$g_{moon} \approx \frac{g_{earth}}{6}$$

A

B

C

D

E

CQ.4.2

Two people apply the same force from the same height to throw two identical balls in the air. Will the balls necessarily travel the same distance? Why or why not?

- a) No, the balls will not necessarily travel the same distance because the gravitational force acting on them is different.
- b) No, the balls will not necessarily travel the same distance because the angle at which they are thrown may differ.
- c) Yes, the balls will travel the same distance because the gravitational force acting on them is the same.
- d) Yes, the balls will travel the same distance because the angle at which they are thrown may differ.

A

B

C

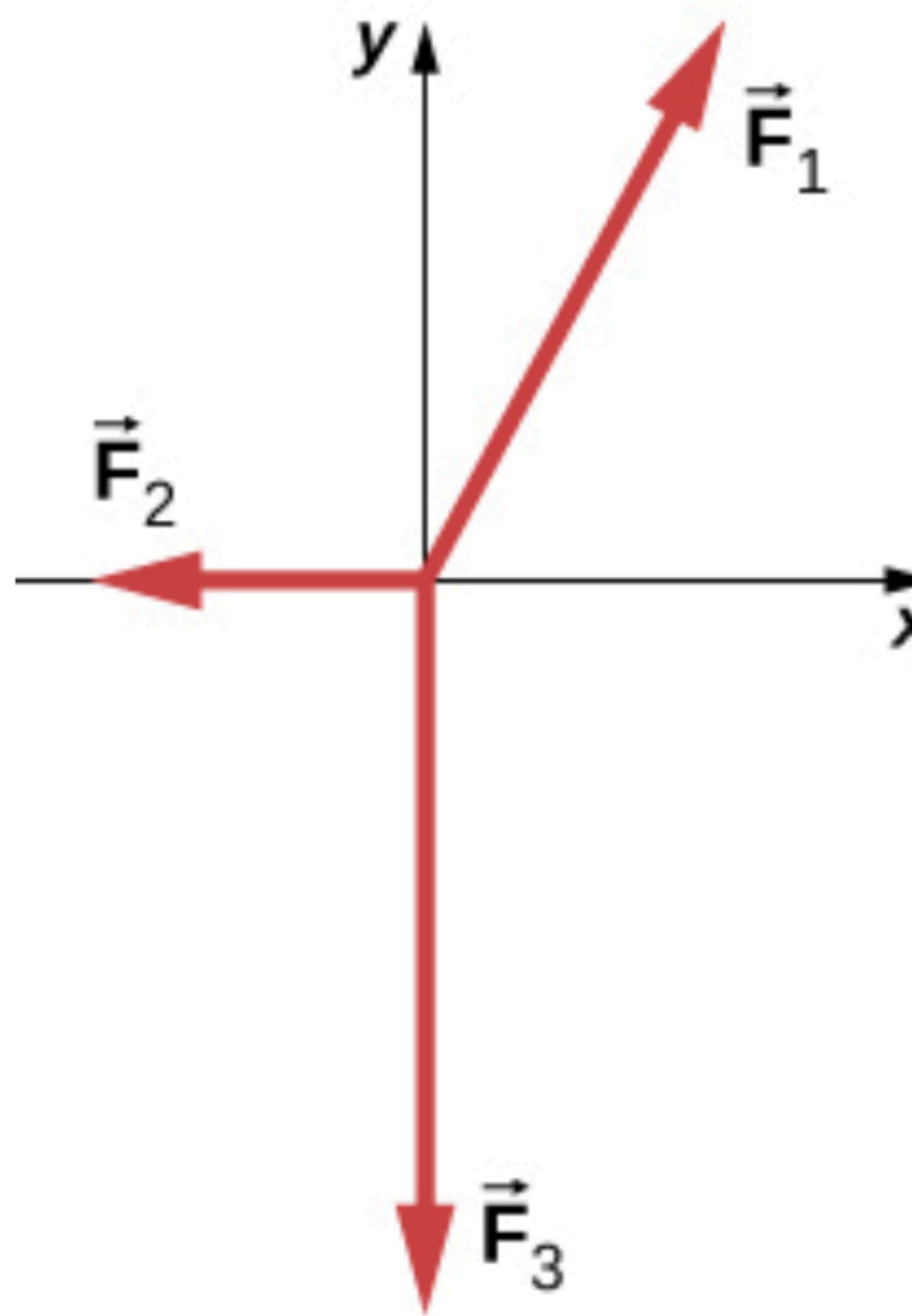
D

E

Activity:

Worked Problem

20 . A telephone pole has three cables pulling as shown from above, with $\vec{F}_1 = (300.0\hat{i} + 500.0\hat{j})$, $\vec{F}_2 = -200.0\hat{i}$, and $\vec{F}_3 = -800.0\hat{j}$. (a) Find the net force on the telephone pole in component form. (b) Find the magnitude and direction of this net force.



See you next class!

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