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# Physics 111 - Class 8A

## Work & Kinetic Energy

October 25, 2021

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# Class Outline

- Logistics / Announcements
- Mid-course Feedback Results
- Introduction to Chapter 7
- Clicker Questions
- Activity: Worked Problems

# Logistics/Announcements

- Lab this week: Lab 5
- HW7 due this week on Thursday at 6 PM
- Learning Log 7 due on Saturday at 6 PM
- HW and LL deadlines have a 48 hour grace period
- Test/Bonus Test: Test 4 available this week (Chapters 5 & 6)
- 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

## Work, Energy, and Power



Work, Energy, and Power: Crash Course Physics #9

Copy link

# WORK, ENERGY, AND POWER



Watch on YouTube

## Required Videos

### 1. Introduction to Work with Examples



Introduction to Work with Examples

Copy link

video 1

- Video 2
- Video 3
- Video 4
- Video 5
- Video 6
- Video 7
- Video 8

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  - ▶ 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
  - ▼ 7 Work and Kinetic Energy
    - Introduction**
    - 7.1 Work
    - 7.2 Kinetic Energy
    - 7.3 Work-Energy Theorem
    - 7.4 Power
    - ▶ Chapter Review
  - ▶ 8 Potential Energy and Conservation of Energy
  - ▶ 9 Linear Momentum and Collisions
  - ▶ 10 Fixed-Axis Rotation
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  - ▶ 13 Gravitation
  - ▶ 14 Fluid Mechanics

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**My highlights**



**Figure 7.1** A sprinter exerts her maximum power with the greatest force in the short time her foot is in contact with the ground. This adds to her kinetic energy, preventing her from slowing down during the race. Pushing back hard on the track generates a reaction force that propels the sprinter forward to win at the finish. (credit: modification of work by Marie-Lan Nguyen)

## Chapter Outline

- [7.1 Work](#)
- [7.2 Kinetic Energy](#)
- [7.3 Work-Energy Theorem](#)
- [7.4 Power](#)

In this chapter, we discuss some basic physical concepts involved in every physical motion in the universe, going beyond the concepts of force and change in motion, which we discussed in [Motion in Two and Three Dimensions](#) and [Newton's Laws of Motion](#). These concepts are work, kinetic energy, and power. We explain how these quantities are

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# Energy

- In the first part of the course, we talked about the motion of objects and systems (Kinematics) and “tools of the trade” like trigonometry, derivatives, integrals, and vector decomposition.
- In the second part of the course, we talked about how Forces affect the motion of objects and systems.
- In the last part of the course, we will talk about Energy; which is a very helpful accounting tool to help us understand what happens when Forces are applied to other objects.

# Monday's Class

7.1 Work

# Definition of Energy

“Energy” is an abstract concept and you can think of it as an accounting system to help us understand the world.

A system has “energy” if it has the ability to do Work.

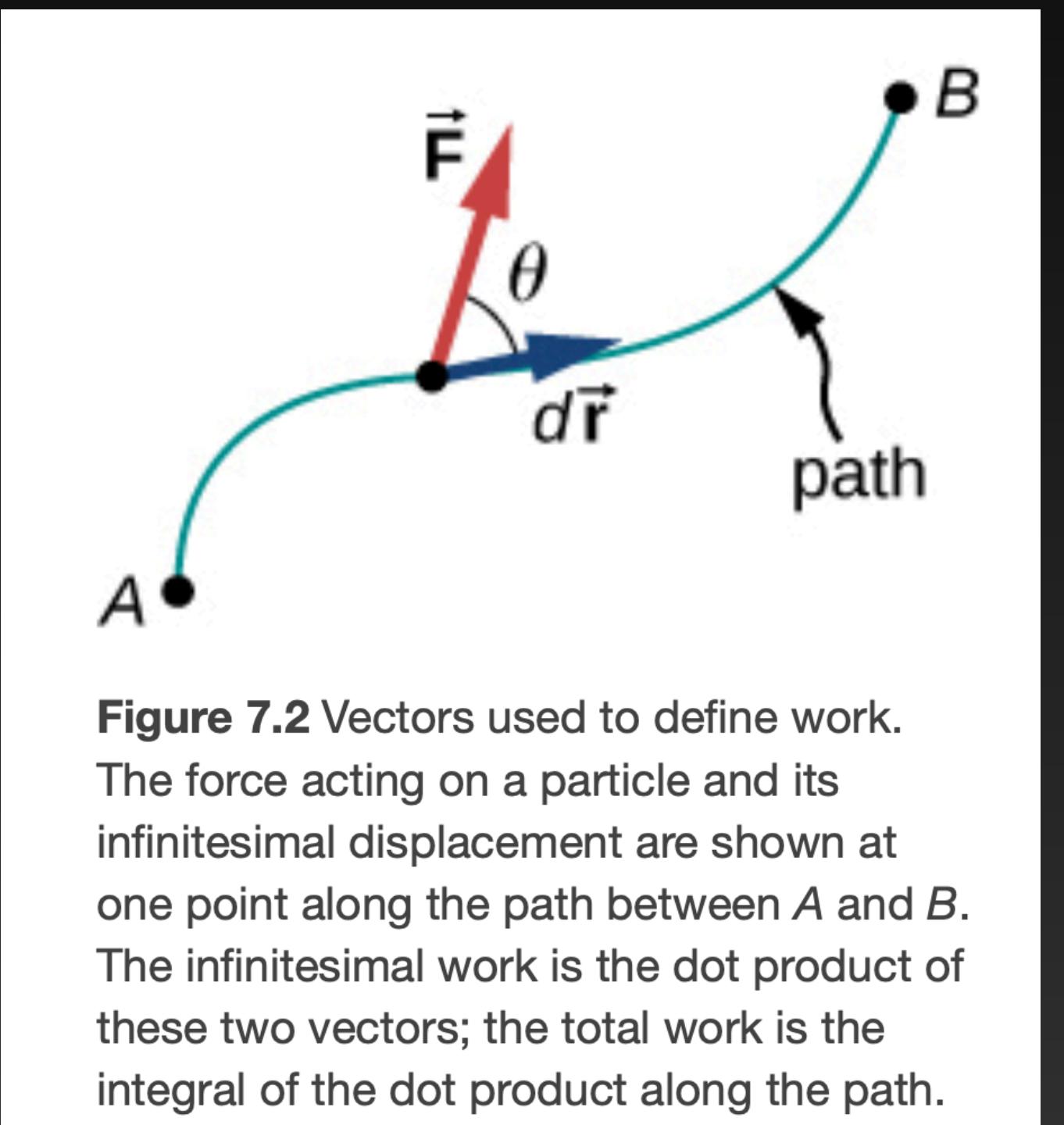
Energy is transferred (or transformed) when Work is done.

Energy is a “scalar” quantity (remember scalars can be positive or negative).

# Definition of Work

Work is done whenever an applied (external) force causes displacement.

$$W = \int \vec{F} \cdot d\hat{\vec{r}}$$



# Definition of Work

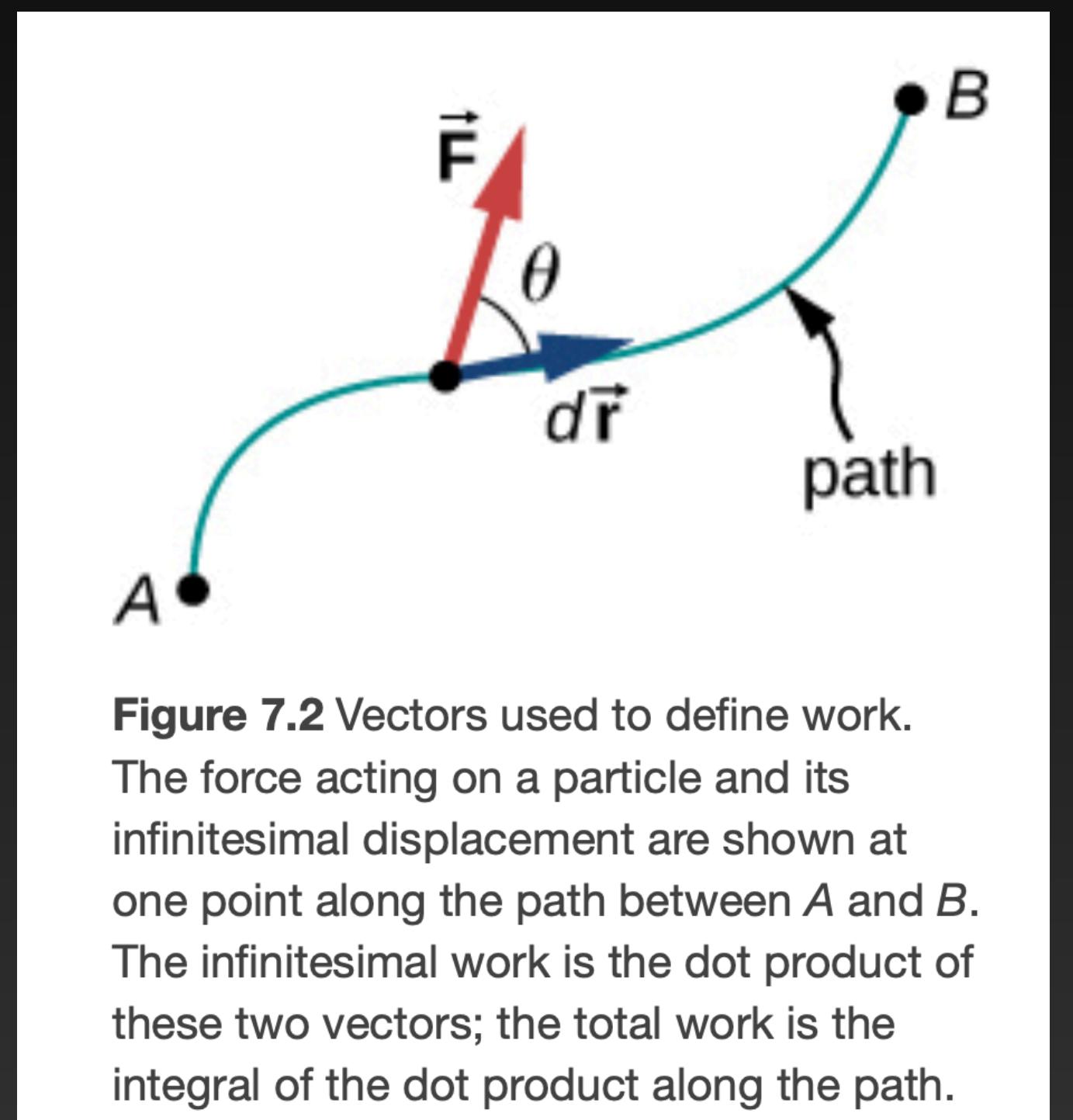
Work is done whenever an applied (external) force causes displacement.

$$W = \int \vec{F} \cdot d\hat{\vec{r}}$$

When  $F$  is constant:

$$W = Fd\cos(\theta)$$

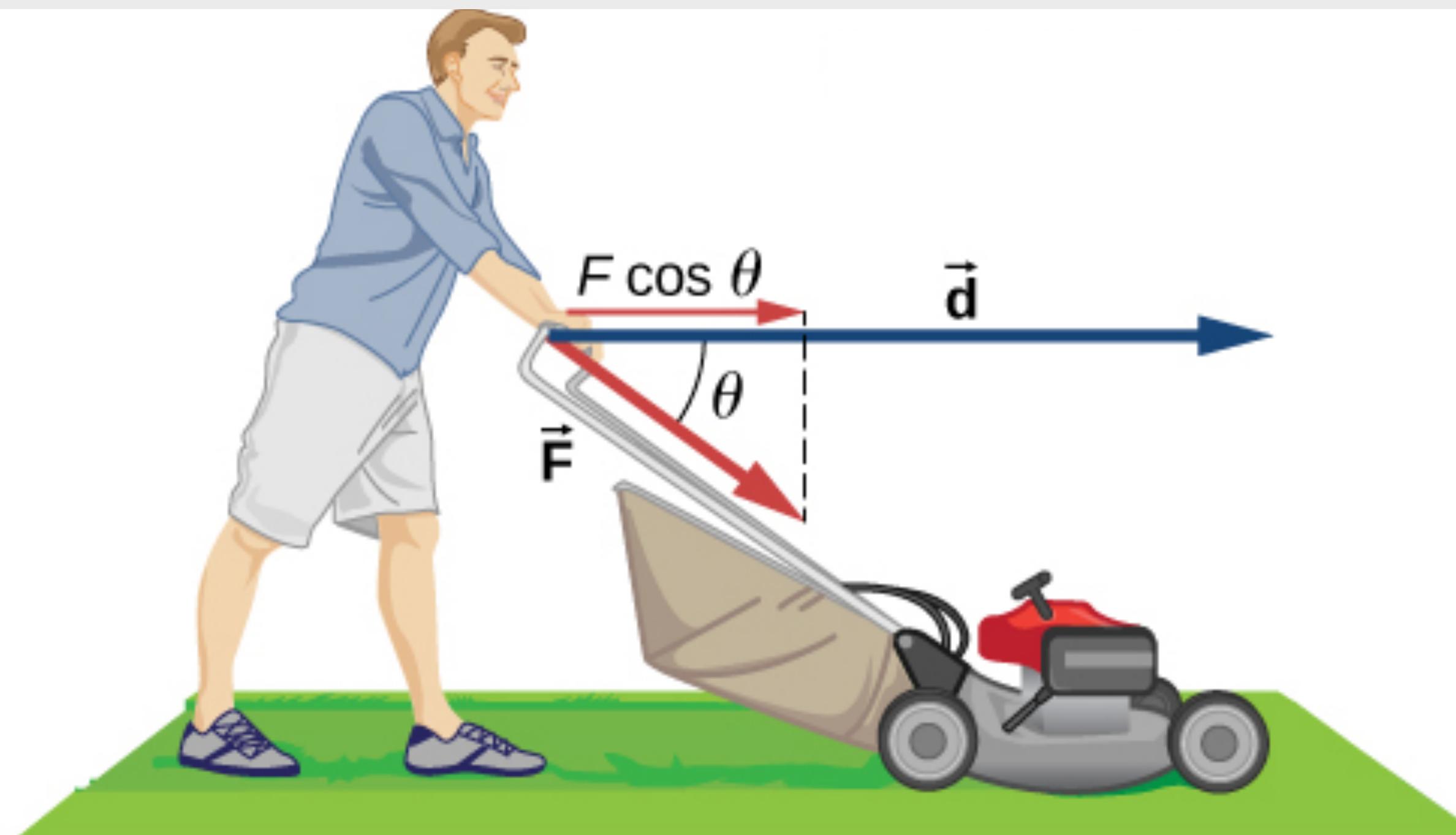
No matter how complex the problem seems,  
this always holds true!



**Figure 7.2** Vectors used to define work. The force acting on a particle and its infinitesimal displacement are shown at one point along the path between A and B. The infinitesimal work is the dot product of these two vectors; the total work is the integral of the dot product along the path.

**EXAMPLE 7.1****Calculating the Work You Do to Push a Lawn Mower**

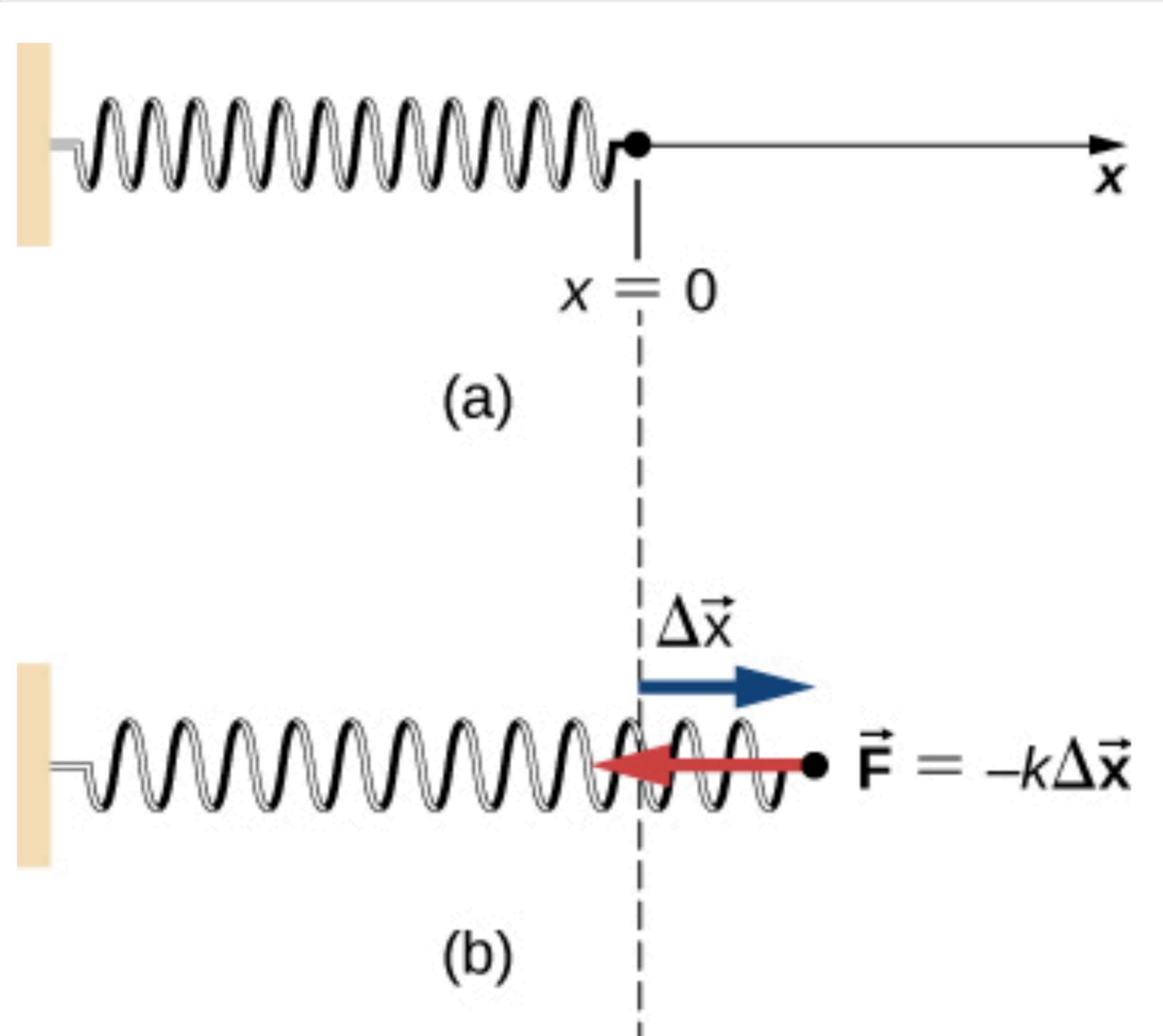
How much work is done on the lawn mower by the person in [Figure 7.3\(a\)](#) if he exerts a constant force of 75.0 N at an angle  $35^\circ$  below the horizontal and pushes the mower 25.0 m on level ground?



(a)

**EXAMPLE 7.5****Work Done by a Spring Force**

A perfectly elastic spring requires 0.54 J of work to stretch 6 cm from its equilibrium position, as in [Figure 7.7\(b\)](#). (a) What is its spring constant  $k$ ? (b) How much work is required to stretch it an additional 6 cm?



# Key Equations

Work done by a force over an infinitesimal displacement

$$dW = \vec{F} \cdot d\vec{r} = |\vec{F}| |d\vec{r}| \cos \theta$$

Work done by a force acting along a path from  $A$  to  $B$

$$W_{AB} = \int_{\text{path } AB} \vec{F} \cdot d\vec{r}$$

Work done by a constant force of kinetic friction

$$W_{\text{fr}} = -f_k |l_{AB}|$$

Work done going from  $A$  to  $B$  by Earth's gravity, near its surface

$$W_{\text{grav},AB} = -mg (y_B - y_A)$$

Work done going from  $A$  to  $B$  by one-dimensional spring force

$$W_{\text{spring},AB} = -\left(\frac{1}{2}k\right)(x_B^2 - x_A^2)$$

Kinetic energy of a non-relativistic particle

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

Work-energy theorem

$$W_{\text{net}} = K_B - K_A$$

Power as rate of doing work

$$P = \frac{dW}{dt}$$

Power as the dot product of force and velocity

$$P = \vec{F} \cdot \vec{v}$$

# Clicker Questions

# CQ.8.1

**While carrying a heavy box, a boy walks horizontally across a room at a constant speed. True or False: The boy is doing no work on the box.**

- a) True
- b) False

A

B

C

D

E

# CQ.8.2

If force and displacement are in opposite directions, will work be positive or negative?

- a) positive
- b) negative

A

B

C

D

E

# CQ.8.3

How much work is done when a weightlifter lifts a 200 N barbell from the floor to a height of 2 m?

- a) 0 J
- b) 100 J
- c) 200 J
- d) 400 J

A

B

C

D

E

# CQ.8.3

A friend slides a box along a flat floor to you, which you slow by applying a force at a  $30^\circ$  angle. Is the work you do to slow the box positive or negative? If you instead placed a book directly on top of the box as it passed you, what can you say about the work done by the book?

- a) positive; positive work done
- b) positive; negative work done
- c) negative work; positive work done
- d) negative work; no work done

A

B

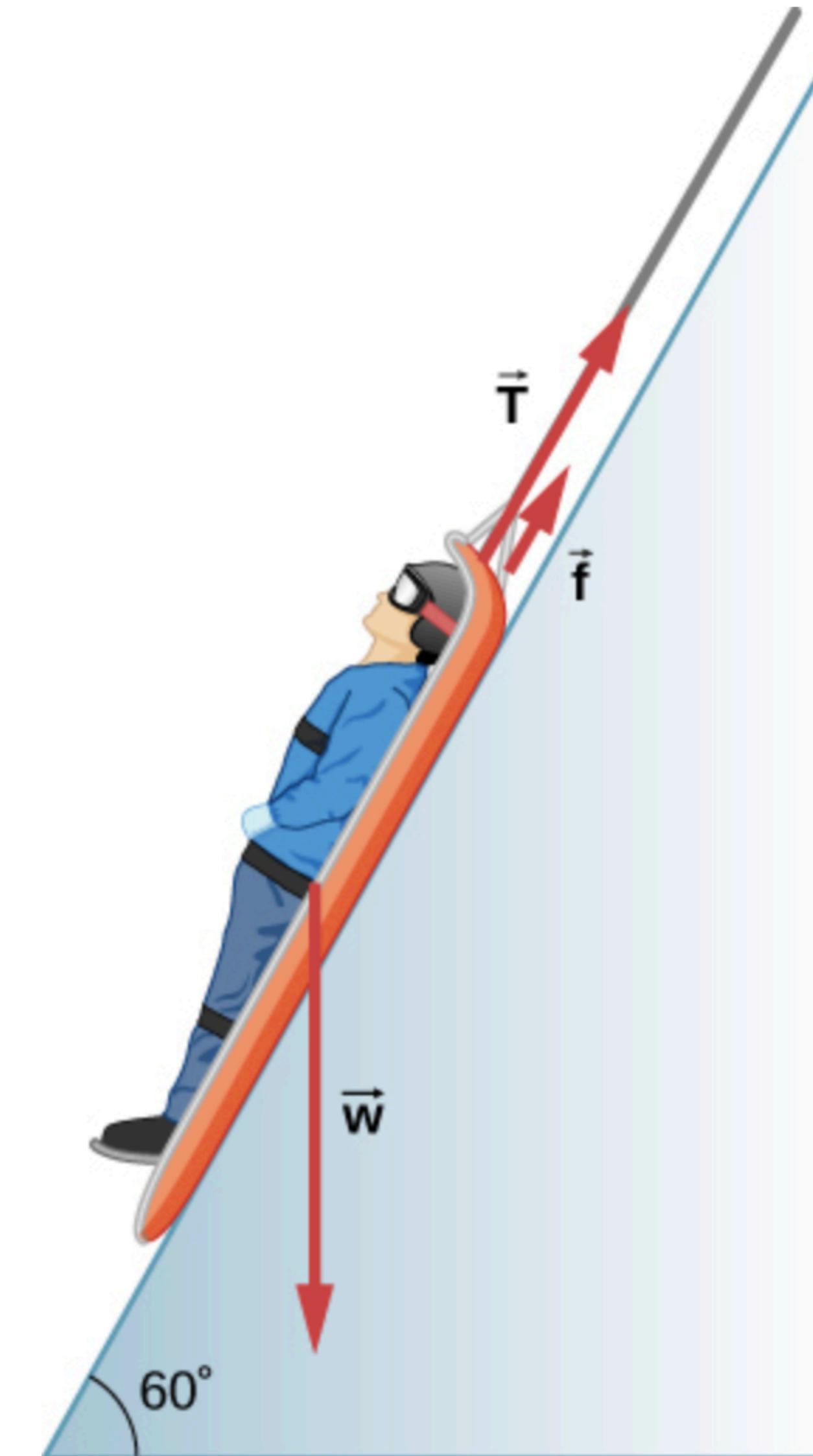
C

D

E

# Activity: Worked Problems

- 30 . Suppose the ski patrol lowers a rescue sled and victim, having a total mass of 90.0 kg, down a  $60.0^\circ$  slope at constant speed, as shown below. The coefficient of friction between the sled and the snow is 0.100. (a) How much work is done by friction as the sled moves 30.0 m along the hill? (b) How much work is done by the rope on the sled in this distance? (c) What is the work done by the gravitational force on the sled? (d) What is the total work done?



# WP 7.2

**36 .** How much work does the force  $F(x) = (-2.0/x)$  N do on a particle as it moves from  $x = 2.0$  m to  $x = 5.0$  m?

**See you next class!**

# Attribution

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