27)

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$$

#1 → Skateboard

#2 → Skateboarder

$m_1 = 7\text{ kg}$ $m_2 = 48\text{kg}$

$v_1 = 2.6\text{m/s}$ $v_2 = 3.2\text{m/s}$

$\underbrace{v_1' = v_2'}_{\text{stick together}} \to v_f$

$$(7)(2.6) + (48)(3.2) = 7v_f + 48v_f$$

$$18.2 + 153.6 = 55v_f$$

$$171.8 = 55v_f$$

$$\boxed{3.1\text{m/s} = v_f}$$

㉘

Before	After
$m_1 = 37kg$ $m_2 = 8kg$	$v_1' = 0.5 m/s$
$v_1 = 0 m/s$ $v_2 = 0 m/s$	$v_2' = ?$

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$

$$(37)(0) + (8)(0) = 37(0.5) + 8 v_2'$$

$$0 = 18.5 + 8 v_2'$$

$$-18.5 = 8 v_2'$$

$$\boxed{-2.3 m/s = v_2'}$$

(31) Before | After

$m_1 = 60\,\text{kg} \quad v_1 = 0$ | $v_1' = ?$

$m_2 = 3\,\text{kg} \quad v_2 = 4.5\,\text{m/s}$ | $\underbrace{v_2' = v_1'}_{\text{stick together}} \rightarrow v_f$

$$m_1 v_1 + m_2 v_2 = m_1 v_f + m_2 v_f$$

$$60(0) + (3)(4.5) = 60 v_f + 3 v_f$$

$$13.5 = 63 v_f$$

$$\boxed{0.21\,\text{m/s} = v_f}$$

$$mv = p$$

(b) $\underset{J}{\text{Impulse}} = Ft = m\Delta v$

$$= m(v_f - v_0)$$

$$= 60(0.21)$$

$$= 12\,\text{kg m/s}$$

UNIT 3

Work, Power and Energy

Chapter 6 - Work, Power and Energy (Page 216)

Types of Energy

mechanical energy = kinetic energy + potential energy

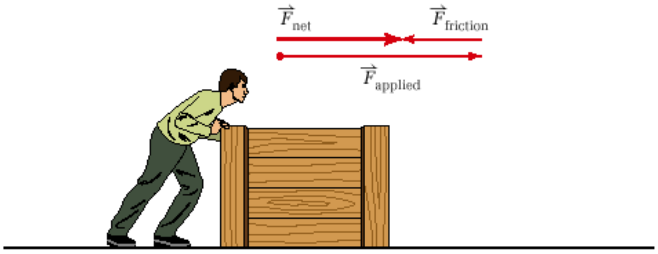
$\frac{1}{2}mv^2$

Work

Work is a transfer of energy. Work is always done on an object and results in a change in that object. A force does work on an object if it causes the object to move.

Work is the product of the magnitude of an individual force acting on an object (not the net force acting on the object) and the magnitude of the displacement of the object. The force and displacement must be parallel to one another.

Figure 6.3 When you were determining the motion of objects in Chapter 4, you used the net force acting on the object. The net force is really the vector sum of all of the forces acting on the object. When calculating work, you determine the work done by one specific force, not the net force.



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$\boxed{W = F_{\parallel}\Delta d}$ → $\boxed{W = Fd}$

parallel

W -> work

$F_{\parallel}$ -> magnitude of individual force

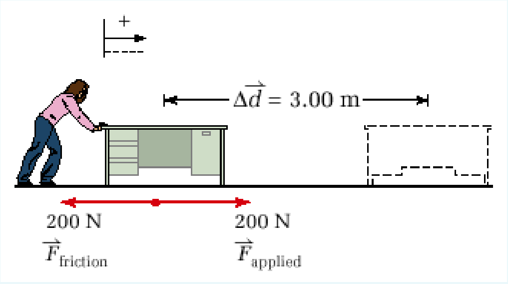
Δd -> magnitude of displacement

NOTE: Force and displacement are vectors. Work is a scalar.

MODEL PROBLEM

Determining the Amount of Work Done

A physics student is rearranging her room. She decides to move her desk across the room, a total distance of 3.00 m. She moves the desk at a constant velocity by exerting a horizontal force of 2.00×10^2 N. Calculate the amount of work the student did on the desk in moving it across the room.



$W = Fd$

$= (200 N)(3 m)$

$\boxed{= 600 Nm}$

Page 221, PP #1-3

PRACTICE PROBLEMS

1. A weight lifter, Paul Anderson, used a circular platform attached to a harness to lift a class of 30 children and their teacher. While the children and teacher sat on the platform, Paul lifted them. The total weight of the platform plus people was 1.1×10^4 N. When he lifted them a distance of 52 cm, at a constant velocity, how much work did he do? How high would you have to lift one child, weighing 135 N, in order to do the same amount of work that Paul did?

2. A 75 kg boulder rolled off a cliff and fell to the ground below. If the force of gravity did 6.0×10^4 J of work on the boulder, how far did it fall?

3. A student in physics lab pushed a 0.100 kg cart on an air track over a distance of 10.0 cm, doing 0.0230 J of work. Calculate the acceleration of the cart. (Hint: Since the cart was on an air track, you can assume that there was no friction.)

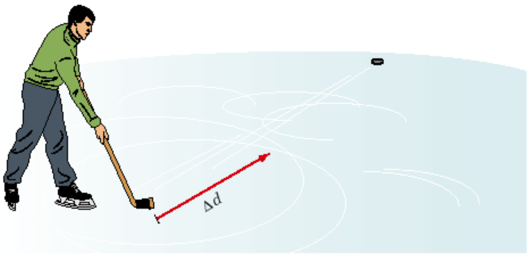
Three Cases
When No Work is Done
(Page 222)

Case 1: Applying a Force That Does Not Cause Motion

Consider the energy that you could expend trying to move a house. Although you are pushing on the house with a great deal of force, it does not move. Therefore, the work done on the house, according to the equation for work, is zero (see Figure 6.4). In this case, your muscles feel as though they did work; however, they did no work on the house. The work equation describes work done by a force that moves the object on which the force is applied. Recall that work is a transfer of energy to an object. In this example, the *condition* of the house has not changed; therefore, no work could have been done on the house.

Case 2: Uniform Motion in the Absence of a Force

Recall from Chapter 5 that Newton's first law of motion predicts that an object in motion will continue in motion unless acted on by an *external* force. A hockey puck sliding on a frictionless surface at constant speed is moving and yet the work done is still zero (see Figure 6.5). Work was done to start the puck moving, but because the surface is frictionless, a force is not required to keep it moving; therefore, no work is done on the puck to keep it moving.



Case 3: Applying a Force That Is Perpendicular to the Motion

Assume that you are carrying your physics textbook down the hall, at constant velocity, on your way to class. Your hand applies a force directly upward to your textbook as you move along the hallway. When considering the work done on the textbook by your hand, you can see that the upward force is perpendicular (i.e., at 90°) to the displacement. In this case, the work done by your hand on the textbook is zero (see Figure 6.6). It is important to note that your hand does do work on the textbook to accelerate it when you begin to move, but once you and the textbook are moving at a constant velocity, you are no longer doing work on the book.

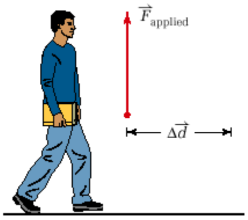
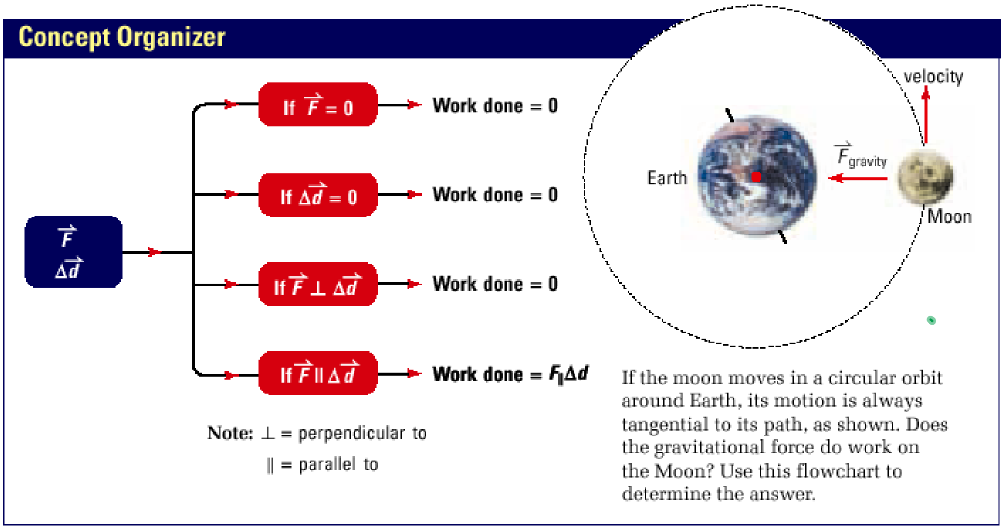


Figure 6.6 You are exerting an upward force (against gravity) on your book to prevent it from falling. However, since this force is perpendicular to the motion of the book, it does no work on the book.

Concept Organizer



If the moon moves in a circular orbit around Earth, its motion is always tangential to its path, as shown. Does the gravitational force do work on the Moon? Use this flowchart to determine the answer.

Figure 6.7 Making decisions about work done

P.225.

PRACTICE PROBLEMS

4. With a 3.00×10^2 N force, a mover pushes a heavy box down a hall. If the work done on the box by the mover is 1.90×10^3 J, find the length of the hallway.

5. A large piano is moved 12.0 m across a room. Find the average horizontal force that must be exerted on the piano if the amount of work done by this force is 2.70×10^3 J.

6. A crane lifts a 487 kg beam vertically at a constant velocity. If the crane does 5.20×10^4 J of work on the beam, find the vertical distance that it lifted the beam.

7. A teacher carries his briefcase 20.0 m down the hall to the staff room. The teacher's hand exerts a 30.0 N force upward as he moves down the hall at constant velocity.

(a) Calculate the work done by the teacher's hand on the briefcase.

(b) Explain the results obtained in part (a).

8. A 2.00×10^2 N force acts horizontally on a bowling ball over a displacement of 1.50 m. Calculate the work done on the bowling ball by this force.

9. The *Voyager* space probe has left our solar system and is travelling through deep space, which can be considered to be void of all matter. Assume that gravitational effects may be considered negligible when *Voyager* is far from our solar system.

(a) How much work is done on the probe if it covers 1.00×10^6 km travelling at 3.00×10^4 m/s?

(b) Explain the results obtained in part (a).

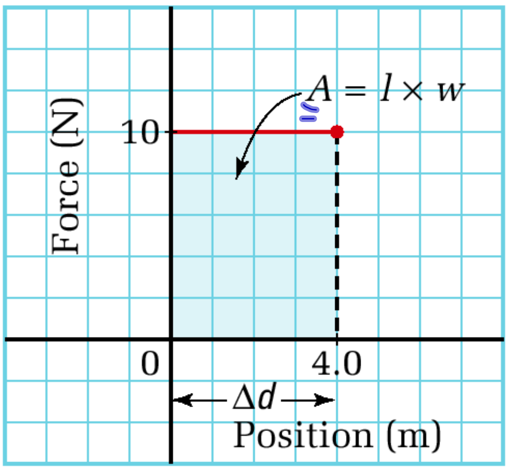
10. An energetic group of students attempts to remove an old tree stump for use as firewood during a party. The students apply an average upward force of 650 N. The 865 kg tree stump does not move after 15.0 min of continuous effort, and the group gives up.

(a) How much work did the students do on the tree stump?

(b) Explain the results obtained in part (a).

Work Done by Forces
(Page 225)

Force vs. Position



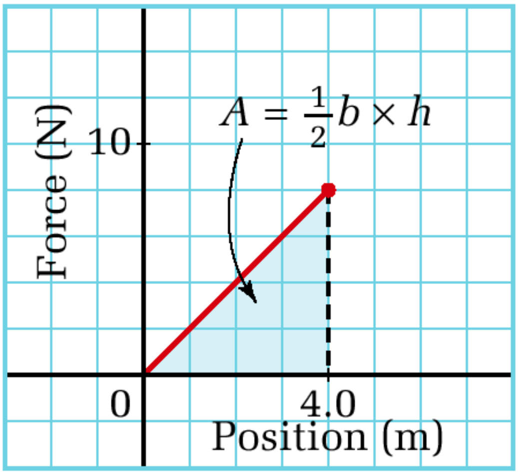
Constant Force

Area = l x w

Area = Fd

Area = Work

Force vs. Position



Force Not Constant
(increasing steadily)

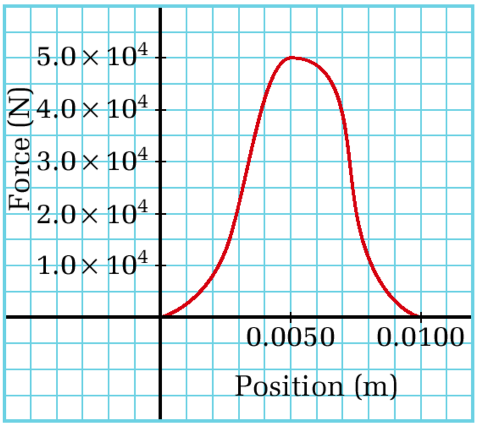
$A = \frac{1}{2} b \times h$

$A = \frac{1}{2}(dF)$ or $A = \frac{1}{2} Fd$

$W = \frac{1}{2} Fd$

* Average force is used.

Force vs. Position



Force Not Constant

Force changes. It reaches a maximum then falls back to zero.

Area = Work Done

Use Calculus to find work.

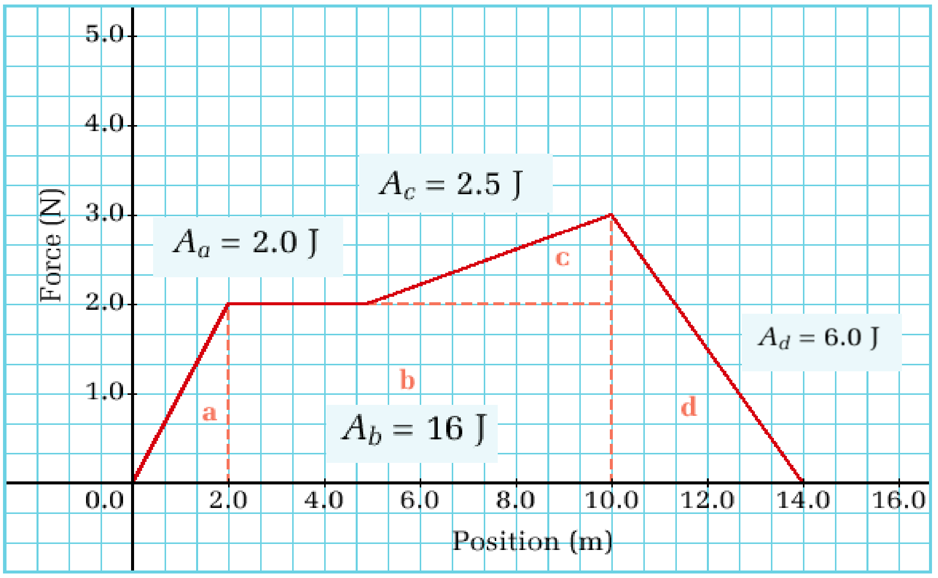
DR

To find the work done, count the number of squares and estimate the area of the partial squares.

MODEL PROBLEM

Estimating Work from a Graph

Determine the amount of work done by the changing force represented in the force-versus-position plot shown here.



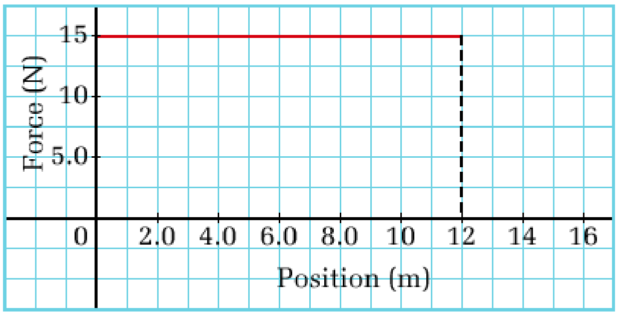
$$\begin{aligned} A_T &= A_a + A_b + A_c + A_d \\ &= 2.0\text{ J} + 16.0\text{ J} + 2.5\text{ J} + 6.0\text{ J} \\ &= 26.5\text{ J} \end{aligned}$$

$$W = 26.5\text{ J} \cong 27\text{ J}$$

PRACTICE PROBLEMS

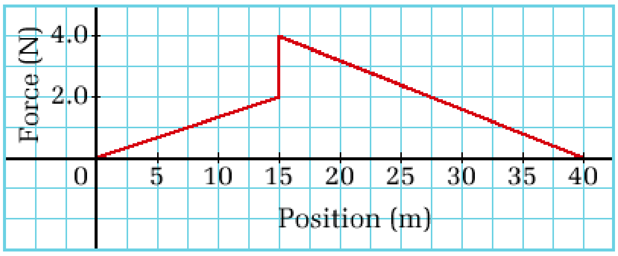
11. Determine the amount of work done by the forces represented in the four force-versus-position plots that follow.

A



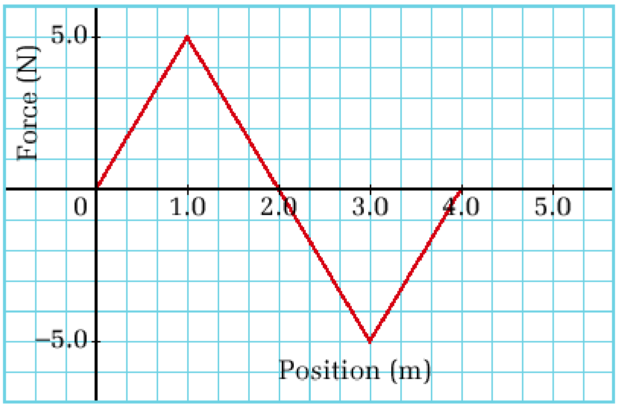
1.8 x 10^2 J

B



65 J

C



0 J

12. Draw a force-versus-position plot that represents a constant force of 60 N exerted on a Frisbee™ over a distance of 80.0 cm. Show the work done on the Frisbee™ by appropriately shading the graph.