 NEWTON’S

THIRD LAW

OF MOTION—

ACTION AND

REACTION

Objectives

• Define force as part of an

 interaction. (7.1)

• State Newton’s third law of

 motion. (7.2)

• Describe how to identify a pair

 of action–reaction forces. (7.3)

• Explain why the accelerations

 caused by an action force and

 by a reaction force do not have

 to be equal. (7.4)

• Explain why an action force is

 not cancelled by the reaction

 force. (7.5)

• Explain how a horse-cart

 system accelerates. (7.6)

• Explain what must occur in

 every interaction between

 things. (7.7)

NEWTON’S THIRD LAW OF

MOTION—ACTION AND REACTION

THE BIG

........

IDEA

For every force, there is an equal

and opposite force.

discover!

MATERIALS

 two spring

balances, two bathroom scales

 f you lean over too far, you’ll fall. But

 if you lean over with your hand out-

 stretched and make contact with a

wall, you can do so without falling.

When you push against the wall, it

pushes back on you. That’s why you

are supported. Ask your friends

why you don’t topple over. How

many will answer, “Because the

wall is pushing on you and hold-

ing you in place”? Probably not

very many people, unless they’re

physics types, realize that walls

can push on us every bit as much as

we push on them.7.0 Similarly, kayak

paddles that push water backward

are pushed forward by the water.

I

 In the

interaction between two

spring balances or two

bathroom scales, the spring

balances and the bathroom

scales always have the same

reading.

EXPECTED OUTCOME

ANALYZE AND CONCLUDE

discover!

Can There Be Only One Force In an

Interaction?

1. Connect the hooks of two spring balances.

 Have a tug of war with a classmate. Observe

 the reading on the scales during the tug of

 war. (Caution: Don’t pull too hard!)

2. Try to have one person pull harder than the

 other. Note the scale readings again.

3. With your classmate, hold two bathroom

 scales back to back. Now push on the scales

 and share scale readings.

Analyze and Conclude

1. Observing How did readings on the spring

 balances compare throughout your

 tug of war?

2. Predicting Is there some way for one person

 to exert a force without causing the other

 person to interact? Explain.

3. Making Generalizations Why do we say

 forces occur only in pairs?

1. They were the same.

2. No. If one person pulls

 harder, the other person

 must pull harder back in

 order for there still to be an

 interaction.

3. A force is always part of an

 interaction that involves

 another force.

106

106

7.1 Forces and

Interactions

Key Term

interaction

 Teaching Tip Touch your

desk and state, “I can’t touch this

desk without the desk touching

me; I can’t exert a force on a

body without that body exerting

a force on me. In all cases of

contact there is a twoness—

contact requires two objects.”

FIGURE 7.1

When you push on the wall,

the wall pushes on you.

FIGURE 7.2

The interaction that drives the nail is the

same as the one that halts the hammer.

7.1 Forces and Interactions

In the simplest sense, a force is a push or a pull. Looking closer, how-

 A forceever, Newton realized that a force is not a thing in itself.

is always part of a mutual action that involves another force. A

mutual action is an interaction between one thing and another. For

example, consider the interaction between a hammer and a nail, as

shown in Figure 7.2. A hammer exerts a force on the nail and drives

it into a board. But this force is only half the story, for there must

also be a force exerted on the hammer to halt it in the process. What

exerts this force? The nail does! Newton reasoned that while the ham-

mer exerts a force on the nail, the nail exerts a force on the hammer.

So, in the interaction between the hammer and the nail, there are

a pair of forces, one acting on the nail and the other acting on the

hammer. Such observations led Newton to his third law: the law of

action and reaction.

CONCEPT

think!

Does a stick of dynamite

contain force? Explain.

Answer: 7.1

......

CHECK

Why do forces always occur in pairs?

Link to BIOLOGY

Action–Reaction in Action Why

do migrating birds, such as geese,

fly in a V formation? The answer is

simple, physics! The bird’s wings

deflect air downward and the

air pushes the bird upward. But

the story doesn’t end there. The

downward-moving air meets the

air below and swirls upward.

CHAPTER 7

 A force is always part

CHECK of a mutual action

that involves another force.

CONCEPT

This upward-swirling air creates an

updraft, which is strongest off to

the side of the bird. A trailing bird

positions itself to get added lift

from the updraft, thus conserving its

energy. This bird, in turn, creates an

updraft for a following bird, and so

on. The result is a flock flying in a

V formation.

NEWTON’S THIRD LAW OF MOTION— ACTION AND REACTION

Teaching Resources

• Reading and Study

 Workbook

• PresentationEXPRESS

• Interactive Textbook

• Conceptual Physics Alive!

 DVDs Newton’s Third Law

......

107

107

7.2 Newton’s Third

Law

Key Terms

Newton’s third law, action force,

reaction force

 Teaching Tip Stress that

forces always occur in pairs and,

like the sound of one hand

clapping, the action of one force

alone is physically impossible.

7.2 Newton’s Third Law

Newton’s third law describes the relationship between two forces

in an interaction. Newton’s third law states that whenever one

object exerts a force on a second object, the second object exerts

an equal and opposite force on the first object. One force is called

the action force. The other force is called the reaction force. It

doesn’t matter which force we call action and which we call reaction.

The important thing is that they are partners in a single interac-

tion and that neither force exists without the other. They are equal

in strength and opposite in direction. Newton’s third law is often

stated: “To every action there is always an equal opposing reaction.”

 Look at Figures 7.3 and 7.4. In every interaction, the forces always

occur in pairs. For example, you interact with the floor when you

walk on it. You push against the floor, and the floor simultaneously

pushes against you. Likewise, the tires of a car interact with the road

to produce the car’s motion. The tires push against the road, and the

road simultaneously pushes back on the tires. When swimming, you

interact with the water. You push the water backward, and the water

pushes you forward. Notice that the interactions in these examples

depend on friction. For example, a person trying to walk on ice,

where friction is minimal, may not be able to exert an action force

against the ice. Without the action force there cannot be a reaction

force, and thus there is no resulting forward motion.

CONCEPT

FIGURE 7.3

When the girl jumps to shore,

the boat moves backward.

Demonstration

Extend your hand and show

your class that you can bend

your fingers backward only

very little. Show that if you

push with your other hand,

and thereby apply a force

to them, they will bend

appreciably more. Then show

that an inanimate wall does

the same (as you push against

the wall). State that the wall is

simultaneously pushing

on you as you push on it—

as evidenced by your bent

fingers.

FIGURE 7.4

 Teaching Tip Explain that in

walking, you interact with the

ﬂoor; that is, you push back on

the ﬂoor and the ﬂoor pushes

forward on you. In swimming,

you interact with the water;

that is, you push backward on

the water and the water pushes

forward on you. A balloon pushes

escaping air backward and the

escaping air in turn pushes the

balloon forward, just as a jet

engine works. A car pushes

backward on the road, and the

road pushes forward on the car.

The dog wags the tail and

the tail wags the dog.

CHECK

What happens when an object exerts a force on

another object?

7.3 Identifying Action and Reaction

Sometimes the identity of the pair of action and reaction forces in

an interaction is not immediately obvious. For example, what are the

action and reaction forces in the case of a falling boulder? You might

say that Earth’s gravitational force on the boulder is the action force,

but can you identify the reaction force? Is it the weight of the boul-

der? No, weight is simply another name for the force of gravity. Is it

caused by the ground where the boulder lands? No, the ground does

not act on the boulder until the boulder hits it.

 There is a simple recipe for treating action and reaction forces.

First identify the interaction. Let’s say one object, A, interacts with

another object, B. The action and reaction forces are stated in this

form:

Action: Object A exerts a force on object B.

Reaction: Object B exerts a force on object A.

think!

We know that Earth

pulls on the moon. Does

the moon also pull on

Earth? If so, which pull

is stronger?

Answer: 7.3

 Newton’s third law

CHECK states that whenever

one object exerts a force on a

second object, the second object

exerts an equal and opposite

force on the first object.

CONCEPT

108

......

108

......

7.3 Identifying

 Look at Figure 7.5. To identify a pair of action–reaction

forces, first identify the interacting objects A and B, and if the

action is A on B, the reaction is B on A. So, in the case of the falling

boulder, the interaction during the fall is the gravitational attraction

between the boulder and Earth. If we call the action Earth exerting a

force on the boulder, then the reaction is the boulder simultaneously

exerting a force on Earth.

CONCEPT

You can’t pull on some-

thing unless that some-

thing simultaneously pulls

on you. That’s the law!

Action and Reaction

 Common Misconceptions

Reaction forces occur slightly after

the action force is applied.

 Action and reaction forces

act simultaneously.

FACT

CHECK

How do you identify the acton–reaction forces

in an interaction?

 Teaching Tip Call attention

to the examples in Figure 7.5 and

relate these to the interaction

rule: Object A exerts a force on

object B. Object B exerts a force

on object A. Point out that action

and reaction forces always act on

different objects.

 Ask Identify the action and

reaction pair of forces for the

case of a bat interacting with a

ball. The bat pushes on the ball

and the ball pushes on the bat.

 To identify a pair of

CHECK action–reaction

forces, first identify the

interacting objects A and B, and

if action is A on B, the reaction is

B on A.

CONCEPT

......

discover!

MATERIALS

......

paper and pencil

FIGURE 7.5

In the force-pair between object A and object B, note

that when action is A exerts force on B, the reaction is

simply B exerts force on A.

 Students

will identify the action–

reaction forces.

EXPECTED OUTCOME

THINK

discover!

What are the action–reaction pairs?

1. Each of the drawings below shows the action force on an object.

 Recopy each of the drawings in your notebook.

2. Draw the appropriate vectors showing the reaction forces.

3. Think Specify the action–reaction pairs in each example.

 In each of the four

cases, the reaction arrow

should be equal in size but

opposite in direction to the

action arrow.

Teaching Resources

For: Links on

 action and reaction

Visit: www.SciLinks.org

Web Code: csn – 0703

• Concept-Development

 Practice Book 7-1

• Transparency 10

• Next-Time Question 7-1

CHAPTER 7

NEWTON’S THIRD LAW OF MOTION— ACTION AND REACTION

109

109

7.4 Action and

Reaction on

Different Masses

 Teaching Tip Discuss the

action and reaction forces when

a cannonball is fired from a

cannon. Use the exaggerated

symbol technique to show how

equal forces produce unequal

accelerations when different

masses are involved.

 Ask Apply Newton’s third

law to a tug-of-war. If the action

is you pulling on the rope, is

the reaction force the ground

pushing back on you or your

opponent pulling back on the

rope? Neither; reaction is the

rope pulling back on you—A on B;

B on A!

7.4 Action and Reaction on

 Different Masses

Interestingly enough, in the interaction between the boulder and

Earth, shown in Figure 7.6, the boulder pulls up on Earth with as

much force as Earth pulls down on the boulder. The forces are equal

in strength and opposite in direction. We say the boulder falls to

Earth. Could we also say Earth falls to the boulder? The answer is yes,

but the distance Earth falls is much less. Although the pair of forces

between the boulder and Earth are the same, the masses are quite

unequal. Recall that Newton’s second law states that acceleration is

not only proportional to the net force, but it is also inversely propor-

tional to the mass. Because Earth has a huge mass, we don’t sense its

infinitesimally small acceleration. Although Earth’s acceleration is

negligible, strictly speaking it does move up toward the falling boul-

der. So when you step off a curb, the street actually comes up a tiny

bit to meet you!

Force and Mass A similar example occurs during the firing of a

cannon, as shown in Figure 7.7. When the cannon is fired, there is an

interaction between the cannon and the cannonball. The force the

cannon exerts on the cannonball is exactly equal and opposite to the

force the cannonball exerts on the cannon, so the cannon “kicks.” On

first consideration, you might expect the cannon to kick more than

it does, or you might wonder why the cannonball moves so fast com-

pared with the cannon. According to Newton’s second law, we must

also consider the masses.

 , the massLet F represent both the action and reaction forces;

of the cannon; and m, the mass of the cannonball. Different-sized

symbols indicate the differences in masses and the accelerations. The

acceleration of the cannonball and cannon are

FIGURE 7.6

Earth is pulled up by the

boulder with just as much

force as the boulder is

pulled down by Earth.

m

Cannonball:

F

m

a

Cannon:

m

F

a

FIGURE 7.7

The cannonball undergoes

more acceleration than the

cannon because its mass is

much smaller.

 Do you see why the change in the velocity of the cannonball is

great compared with the change in velocity of the cannon?

 A given force exerted on a small mass produces a greater

acceleration than the same force exerted on a large mass.

110

110

Demonstration

 If we extend the basic idea of a cannon recoiling from the can-

nonball it launches, we can understand rocket propulsion. Consider

air escaping from an untied, blown-up balloon. If the balloon is

released and allowed to move as shown in Figure 7.8, it accelerates

as the air comes out. A rocket accelerates in much the same way—it

continually recoils from the exhaust gases ejected from its engine.

Each molecule of exhaust gas acts like a tiny molecular cannonball

shot downward from the rocket.

 A common misconception is that a rocket, like the one shown

in Figure 7.9, is propelled by the impact of exhaust gases against the

atmosphere. In fact, before the advent of rockets, it was commonly

thought that sending a rocket to the moon was impossible because of

the absence of an atmosphere for the rocket to push against. This is

like saying a cannon won’t recoil unless the cannonball has air to push

against. This is not true! Both the rocket and recoiling cannon acceler-

ate because of the reaction forces created by the “cannonballs” they

fire—air or no air. In fact, rockets work better above the atmosphere

where there is no air resistance.

Lift Using Newton’s third law, we can understand how a helicop-

ter gets its lifting force. The whirling blades are shaped to force air

particles downward (action), and the air forces the blades upward

(reaction). This upward reaction force is called lift. When lift equals

the weight of the craft, the helicopter hovers in midair. When lift is

greater, the helicopter climbs upward.

 Birds and airplanes also fly because of action and reaction forces.

When a bird is soaring, the shape of its wings deflects air downward.

The air in turn pushes the bird up. The slightly tilted wings of an air-

plane also deflect oncoming air downward and produce lift. Airplanes

must continuously push air downward to maintain lift and remain

airborne. This continuous supply of air is produced by the forward

motion of the aircraft, which results from jets or propellers that push

air backward. When the engines push air back, the air in turn pushes

the engines and the plane forward. We will learn later how the curved

surface of an airplane wing enhances the lifting force.

Have a tug of war between

boys and girls in your

classroom. Have the boys

remove their shoes (they

should wear socks) and have

the girls wear rubber-soled

shoes. The fact that the girls

win aptly demonstrates that

the team that wins is the one

that exerts more force against

the floor.

FIGURE 7.8

The balloon recoils from

the escaping air and climbs

upward.

CHECK

......

CONCEPT Why do objects that experience the same amount of

force accelerate at different rates?

 A given force exerted

CHECK on a small mass

produces a greater acceleration

than the same force exerted on a

large mass.

CONCEPT

think!

 A tug of war occurs between boys and girls on a polished floor that’s

somewhat slippery. If the boys are wearing socks and the girls are wearing

rubber-soled shoes, who will surely win, and why?

Answer: 7.4

FIGURE 7.9

The rocket recoils from

the “molecular cannon-

balls” it fires and climbs

upward.

Teaching Resources

• Reading and Study

 Workbook

• PresentationEXPRESS

• Interactive Textbook

• Next-Time Question 7-2

......

CHAPTER 7

NEWTON’S THIRD LAW OF MOTION— ACTION AND REACTION

111

111

7.5 Defining Systems

 Teaching Tip Call attention

to Figure 7.12. Action and

reaction forces are like apples

and oranges in that they act

on different objects. You can’t

cancel a force on an orange with

a force on an apple. This is the

essence of the horse-and-cart

problem.

A system may be as tiny

as an atom or as large as

the universe

7.5 Defining Systems

An interesting question often arises: since action and reaction forces

are equal and opposite, why don’t they cancel to zero? To answer

this question, we must consider the system involved. Consider, for

example, a system consisting of a single orange, as in Figure 7.10. The

dashed line surrounding the orange encloses and defines the system.

The vector that pokes outside the dashed line represents an external

force on the system. The system (that is, the orange) accelerates in

accord with Newton’s second law.

FIGURE 7.10

A force acts on the orange,

and the orange accelerates

to the right.

 In Figure 7.11 we see that this force is provided by an apple,

which doesn’t change our analysis. The apple is outside the system.

The fact that the orange simultaneously exerts a force on the apple,

which is external to the system, may affect the apple (another system),

but not the orange. You can’t cancel a force on the orange with a force

on the apple. So in this case the action and reaction forces don’t can-

cel. Action and reaction forces do not cancel each other when

either of the forces is external to the system being considered.

FIGURE 7.11

The force on the orange,

provided by the apple,

is not cancelled by the

reaction force on the apple.

The orange still accelerates.

 Now let’s consider a larger system, enclosing both the orange and

the apple. We see the system bounded by the dashed line in Figure

7.12a. Notice that the force pair is internal to the orange–apple sys-

tem. Therefore these forces do cancel each other. They play no role

in accelerating the system. A force external to the system is needed

for acceleration. That’s where friction with the floor comes in, as

in Figure 7.12b. When the apple pushes against the floor, the floor

simultaneously pushes on the apple—an external force on the system.

The system accelerates to the right.

112

112

FIGURE 7.12

Consider the larger system of orange

+ apple. a. Action and reaction forces

cancel. b. When the floor pushes on

the apple (reaction to the apple’s push

on the floor), the orange–apple

system accelerates.

 Ask Describe the relative

motions of two people of equal

mass who push off from each

other on slippery ice. Both

people will move at the same

speed, but in opposite directions.

Describe the relative motions of

two people of different masses

who push off each other on the

ice. The more massive person

will move more slowly than the

less massive person. They will,

however, still move in opposite

directions.

CONCEPT

CONCEPT

......

CHECK

Why don’t action–reaction forces cancel each other?

think!

Suppose a friend who hears about Newton’s third law says that you can’t

move a football by kicking it because the reaction force by the kicked ball

would be equal and opposite to your kicking force. The net force would be

zero, so no matter how hard you kick, the ball won’t move! What do you say

to your friend?

Answer: 7.5

FIGURE 7.13

A football is kicked. a. A acts

on B and B accelerates.

b. Both A and C act on B.

They can cancel each other

so B does not accelerate.

Teaching Resources

• Reading and Study

 Workbook

• PresentationEXPRESS

• Interactive Textbook

• Next-Time Questions 7-3,

 7-4, 7-5, 7-6

......

 Inside a baseball are trillions and trillions of interatomic forces

at play. They hold the ball together but play no role in accelerating

the ball. Although every one of the interatomic forces is part of an

action–reaction pair within the ball, they combine to zero, no matter

how many of them there are. A force external to the ball, such as a

swinging bat provides, is needed to accelerate the ball. If the action–

reaction forces are internal to the system, then they cancel and the

system does not accelerate.

 Consider the football in Figure 7.13a. There is one interaction

between the foot and the football, and the ball accelerates. But when

two kicks act on the ball as in Figure 7.13b, no acceleration occurs. In

this case there are two interactions occurring. If the two kicks on the

ball are simultaneous, equal, and opposite, then the net force on the

ball is zero. It is important to notice that the opposing forces act on

the same object, not on different objects, so they do not make up an

action–reaction pair.7.5

 Action and reaction

CHECK forces do not cancel

each other when either of the

forces is external to the system

being considered.

CHAPTER 7

NEWTON’S THIRD LAW OF MOTION— ACTION AND REACTION

113

113

7.6 The Horse–Cart

Problem

 Teaching Tip Discuss action

and reaction in terms of the

horse and cart situation. Point

out that the action force on

the cart is not cancelled by

the reaction force because the

reaction acts on the horse. You

can’t cancel a force on the cart

with a force on something else.

 Ask Consider a tug-of-war

where scales are at opposite

ends of the rope. Is it possible

for the scales to have different

readings when participants pull?

No. Both scales will have the

same reading at any time, no

matter how the rope is pulled.

7.6 The Horse–Cart Problem

A situation similar to the kicked football is shown in the comic strip

“Horse Sense.” Look at Figure 7.14. Here we think of the horse as

believing its pull on the cart will be canceled by the opposite and

equal pull by the cart on the horse, thus making acceleration impos-

sible. This is a classic problem that stumps many college students. By

thinking carefully, you can understand it.

 The horse–cart problem can be looked at from three different

points of view. First, consider the point of view of the farmer, who

is concerned with getting his cart (the cart system) to market. Then,

there is the point of view of the horse (the horse system). Finally,

there is the point of view of the horse and cart together (the horse–

cart system).

 From the farmer’s point of view, the only concern is with the

force that is exerted on the cart system. The net force on the cart,

divided by the mass of the cart, will produce a very real acceleration.

The farmer doesn’t care about the reaction on the horse.

 Now look at the horse system. It’s true that the opposite reac-

tion force by the cart on the horse restrains the horse. Without this

force, the horse could freely gallop to the market. This force tends

to hold the horse back. So how does the horse move forward? The

horse moves forward by interacting with the ground. When the horse

pushes backward on the ground, the ground simultaneously pushes

forward on the horse. If the horse in the horse–cart system

pushes the ground with a greater force than it pulls on the cart,

there is a net force on the horse, and the horse–cart system acceler-

ates. When the cart is up to speed, the horse need only push against

the ground with enough force to offset the friction between the cart

wheels and the ground.

 Finally, look at the horse–cart system as a whole. From this view-

point, the pull of the horse on the cart and the reaction of the cart

on the horse are internal forces, or forces that act and react within

the system. They contribute nothing to the acceleration of the horse–

cart system. They cancel and can be neglected. To move across the

ground, there must be an interaction between the horse–cart system

and the ground. For example, if your car is stalled, you can’t get it

moving by sitting inside and pushing on the dashboard. You must

interact with the ground outside. You must get outside and make the

ground push the car. The horse–cart system is similar. It is the out-

side reaction by the ground that pushes the system.

CONCEPT

FIGURE 7.14

All the pairs of forces that

act on the horse and cart

are shown. The acceleration

of the horse–cart system is

due to the net force F – f.

Difficulties that occur with

action–reaction situations

usually stem from failing to

clearly identify the system in

question. Basically, if you want

to know the effect of a force

or forces on something, call

that something your system.

Define your system by a real

or imaginary dotted line around

that something. Restrict

your attention to the external

forces that originate outside

the dotted line and act on the

system, and not to the forces

that the system may exert on

things external to the dotted

line.

think!

What is the net force that

acts on the cart in Figure

7.14? On the horse? On

the ground?

Answer: 7.6

 If the horse in the

CHECK horse–cart system

pushes the ground with a greater

force than it pulls on the cart,

there is a net force on the horse,

and the horse, and the horse–cart

system accelerates.

CONCEPT

......

CHECK

114

114

......

How does a horse–cart system accelerate?

 Teaching Tip Distinguish

between forces on a system,

and forces by the system on

other objects. In the horse–cart

problem, if the system is the cart,

then the only horizontal force

that acts on the cart is the pull

of the horse (ignoring friction)!

So there is a net force on the

cart and acceleration occurs. If

the system is the horse, draw a

dotted line around the horse.

Two horizontal external forces

act on this system: the reaction

by the cart, and the reaction

by the ground (friction) due to

the horse’s push against the

ground. If the ground’s push is

greater than the cart’s pull, the

horse accelerates (just as much

as the attached cart!). If the

system is both the horse and the

cart, then only one horizontal

external force acts on this system:

the same push of the ground.

Divide this push by the mass of

the horse and cart, and you have

the acceleration of both (the

same as before). Action and

reaction forces do cancel if they

both are within the system being

considered.

Interestingly, if there were

a wind blowing in the same

direction and at the same speed

as the horse and the cart are

moving, there would be no air

resistance. If the wind blew

just enough faster to provide

a force to counteract friction,

the horse could wear roller

skates and simply coast along

with the cart all the way to the

market.

Teaching Resources

• Reading and Study

 Workbook

• PresentationEXPRESS

• Interactive Textbook

CHAPTER 7

NEWTON’S THIRD LAW OF MOTION— ACTION AND REACTION

115

115

7.7 Action Equals

Reaction

 Common Misconception

Action and reaction forces are equal

and opposite only under certain

conditions.

 For every interaction

between things, there is always a

pair of oppositely directed forces

that are equal in strength.

FACT

7.7 Action Equals Reaction

This chapter began with a discussion of how a wall pushes back on

you when you push against it. Suppose that for some reason, you

punch the wall. Bam! Your hand is hurt. Look at the cartoon in

Figure 7.15. Your friends see your damaged hand and ask what hap-

pened. What can you say truthfully? You can say that the wall hit your

hand. How hard did the wall hit your hand? It hit just as hard as you

hit the wall. You cannot hit the wall any harder than the wall can hit

you back.

 Hold a sheet of paper in midair and tell your friends that the

heavyweight champion of the world could not strike the paper with a

force of 200 N (45 pounds). You are correct, because a 200-N interac-

tion between the champ’s fist and the sheet of paper in midair isn’t

possible. The paper is not capable of exerting a reaction force of 200

N, and you cannot have an action force without a reaction force.

Now, if you hold the paper against the wall, that’s a different story.

The wall will easily assist the paper in providing 200 N of reaction

force, and more if needed!

 For every interaction between things, there is always a pair

of oppositely directed forces that are equal in strength. If you push

hard on the world, for example, the world pushes hard on you. If you

touch the world gently, the world will touch you gently in return.

The way you touch others is the way others touch you, as shown in

Figure 7.16.

Demonstration

Drop a sheet of paper and

then punch it in midair. State

that even the heavyweight

boxing champion of the world

couldn’t hit the paper with

a force of 50 pounds. This

is because the paper is not

capable of “hitting back” with

the same amount of force.

A 50-lb interaction between

his fist and the paper is not

possible.

FIGURE 7.15

If you hit the wall, it will hit

you equally hard.

CHECK

FIGURE 7.16

 For every interaction

CHECK between things,

there is always a pair of

oppositely directed forces that

are equal in strength.

CONCEPT

The author and his wife

demonstrate that you can-

not touch without being

touched—Newton’s third law.

Teaching Resources

• Lab Manual 21, 22

• Concept-Development

 Practice Book 7-2

• Reading and Study

 Workbook

• PresentationEXPRESS

• Interactive Textbook

116

......

116

......

CONCEPT What must occur in every interaction

between things?