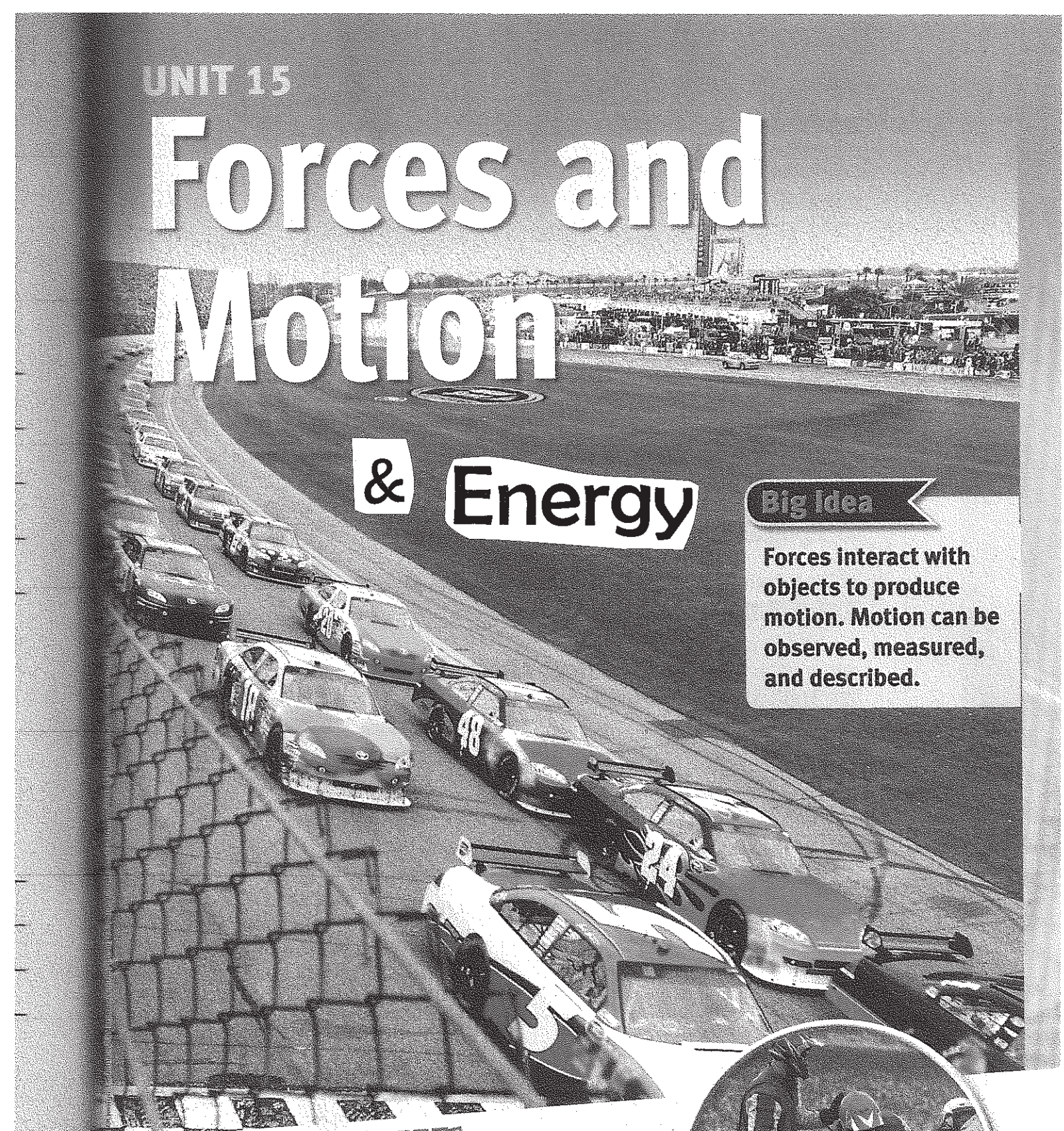
UNIT 15

Forces and Motion & Energy



Big Idea

Forces interact with objects to produce motion. Motion can be observed, measured, and described.

I Wonder Why

Why does a pit crew need to replace the racecar's tires several times during the race? ***Turn the page to find out.***

Here's why Friction gives the racecar traction and allows it to grip the track, but it also produces a lot of heat. The high speed and forceful turns of a race wear tires out quickly.

In this unit, you will explore the Big Idea, the Essential Questions, and the Investigations on the Inquiry Flipchart.

Levels of Inquiry Key ■ DIRECTED ■ GUIDED ■ INDEPENDENT

Track Your Progress

Big Idea Forces interact with objects to produce motion. Motion can be observed, measured, and described.

Essential Questions

Science Notebook

Before you begin each lesson, be sure to write your thoughts about the Essential Question.

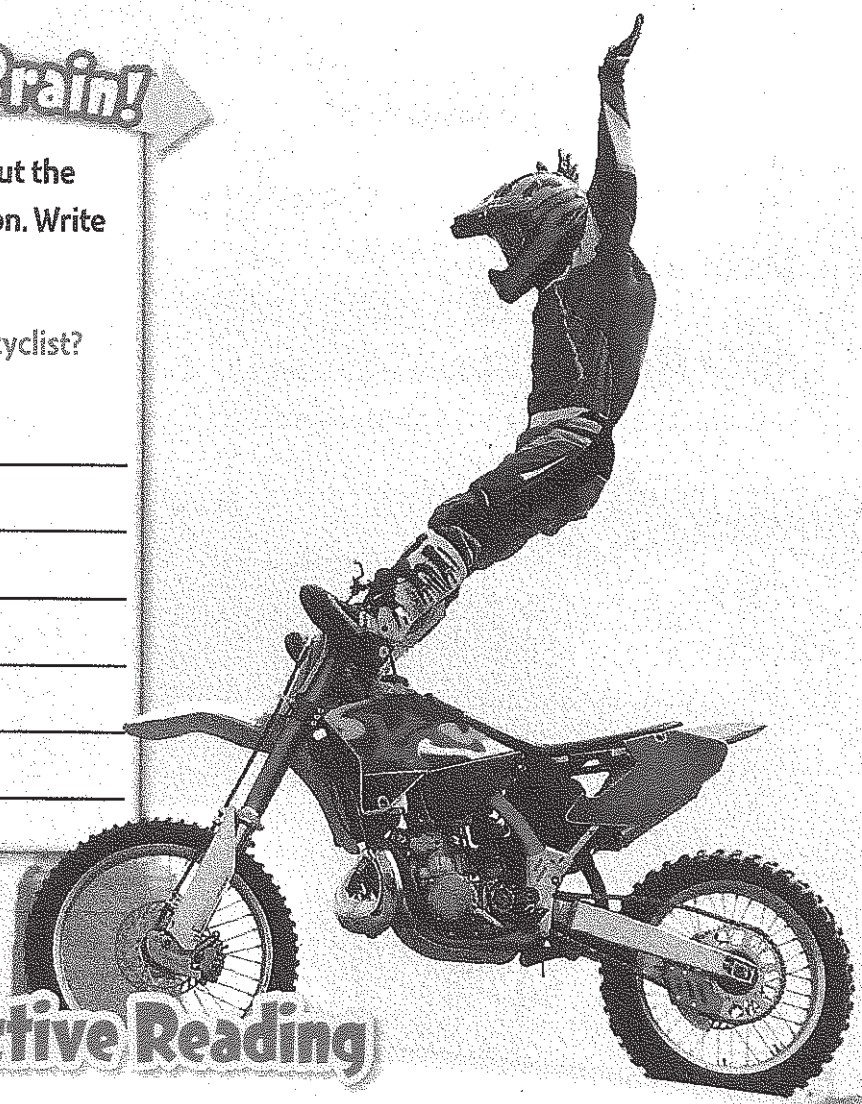
Essential Question

What Are Forces?

Engage Your Brain!

As you read the lesson, figure out the answer to the following question. Write the answer here.

What forces are acting on this cyclist? Are all the forces balanced?



Active Reading

Lesson Vocabulary

List the terms. As you learn about each one, make notes in the Interactive Glossary.

Cause and Effect

Some ideas in this lesson are connected by a cause-and-effect relationship. Why something happens is a cause. What happens as a result of something else is an effect. Active readers look for effects by asking themselves, What happened? They look for causes by asking, Why did it happen?

PUSHING and Pulling

You pull on a door to open it. You lift up a backpack. You push on the pedals of a bike to go faster. What is the relationship between force and motion?

Active Reading As you read this page, underline the effects a force can have on an object.

The horse and the road it is on both exert a force on the cart.

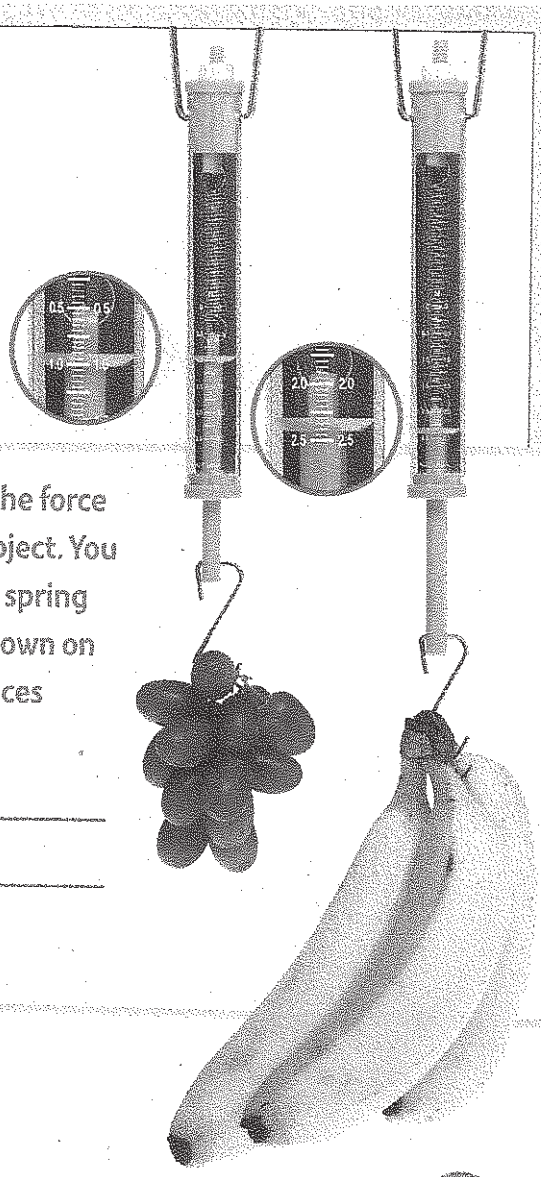
▶ Draw an arrow that shows the direction of the force applied to the cart by the horse.

Changes in motion all have one thing in common. They require a **force**, which is a push or a pull. Forces can cause an object at rest to move. They can cause a moving object to speed up, slow down, change direction, or stop. Forces can also change an object's shape.

Forces are measured with a spring scale in units called newtons (N). The larger the force, the greater the change it can cause to the motion of an object. Smaller forces cause smaller changes. Sometimes more than one force can act together in a way that does not cause a change in motion.

When the rowers pull back on the oars, the oars push against the water.

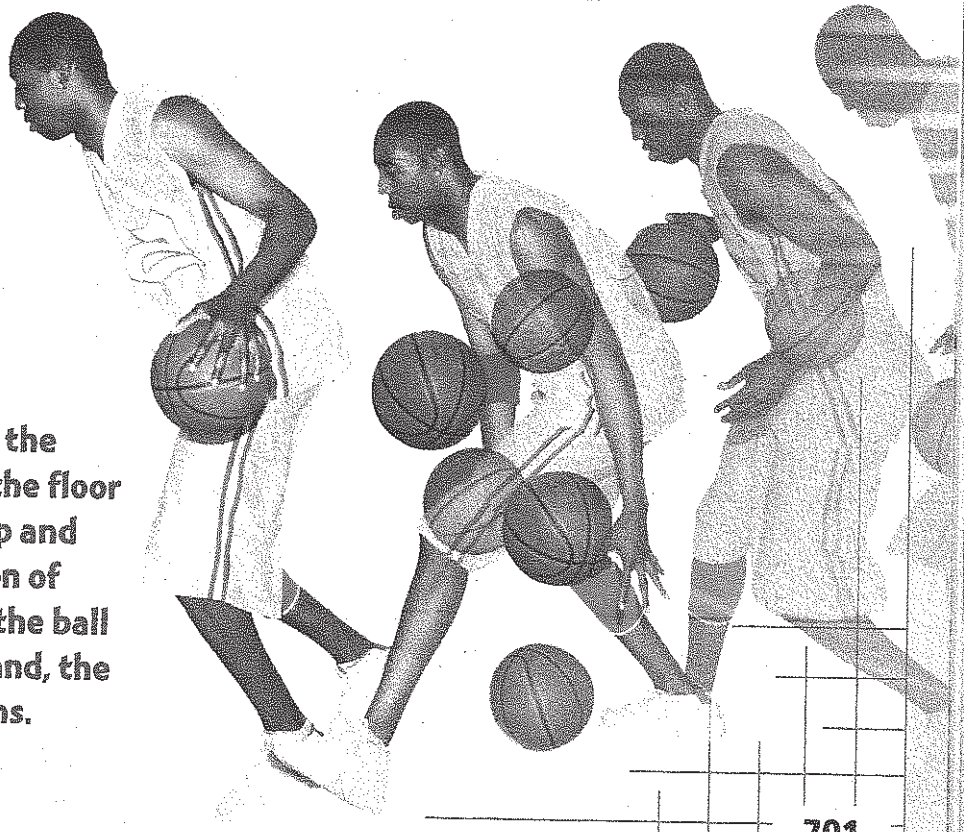
The water pushes back against the oars. This force causes the boat to move.



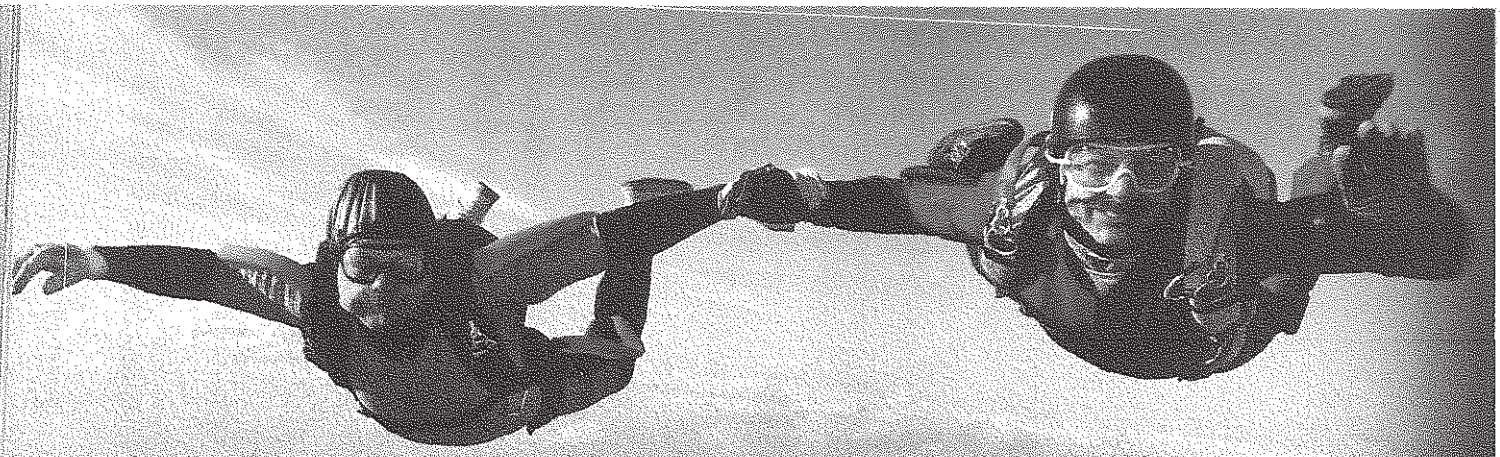
▶ Weight is a measure of the force that gravity exerts on an object. You can measure weight with a spring scale. Record the weight shown on each spring scale in the spaces below.

_____

_____



When the ball hits the floor, the force of the floor makes the ball stop and change its direction of movement. When the ball hits the player's hand, the same thing happens.



TWO COMMON Forces

What do the skydivers and some of the flower petals have in common? They are both falling! What causes this?

Active Reading As you read these pages, circle the sentence that describes a force that causes things to slow down.

► Draw an arrow showing the direction of the gravitational force between Earth and the falling flower petals.

GRAVITY

Gravity is a force of attraction between two objects. The size of this force increases as the mass of the objects increases. It decreases as the distance between the objects increases. Gravity acts on objects even if they are not touching.

Large objects such as Earth cause smaller objects, such as the skydivers, to accelerate quickly. We expect to see things fall toward Earth. However, the force of attraction is the same on both objects. If you place two objects with the same mass in outer space, they will move toward one another. If one object is "above" the other, the bottom object will appear to "fall up" as the other "falls down"!

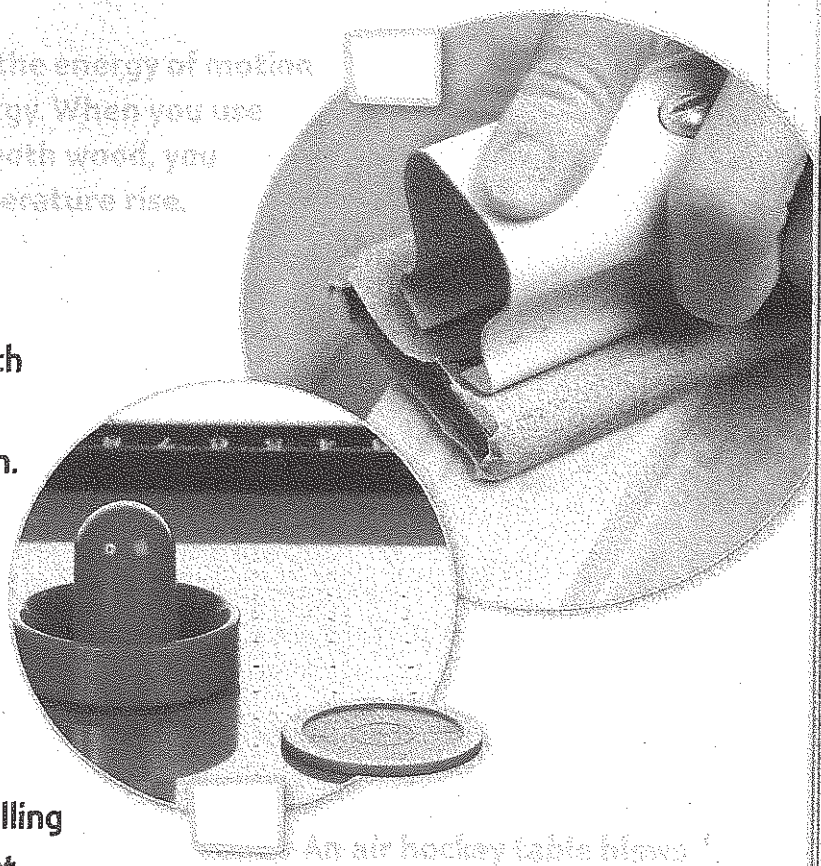
Friction

Is it easier to ride your bike on a smooth road or on a muddy trail? Why?

Friction is a force that opposes motion. Friction acts between two objects that are touching, such as the bike tires and the road. Friction can also exist between air and a moving object. This is called air resistance.

It is easy to slide across smooth ice because it doesn't have much friction. Pulling something across rough sandpaper is a lot harder because there is lots of friction.

Friction changes the energy of motion into thermal energy. When you use sandpaper to smooth wood, you can feel the temperature rise.



An air hockey table blows air upward. This layer of air reduces the surface friction, so the pieces move quickly.

▶ In the pictures on this page, circle the places where there is friction between two objects. In the small boxes, write *Inc* if the object is designed to increase friction and *Dec* if the object is designed to decrease friction.

The tires on this bike are designed to keep the rider from slipping. You have to pedal harder on a rough surface to overcome the force of friction.

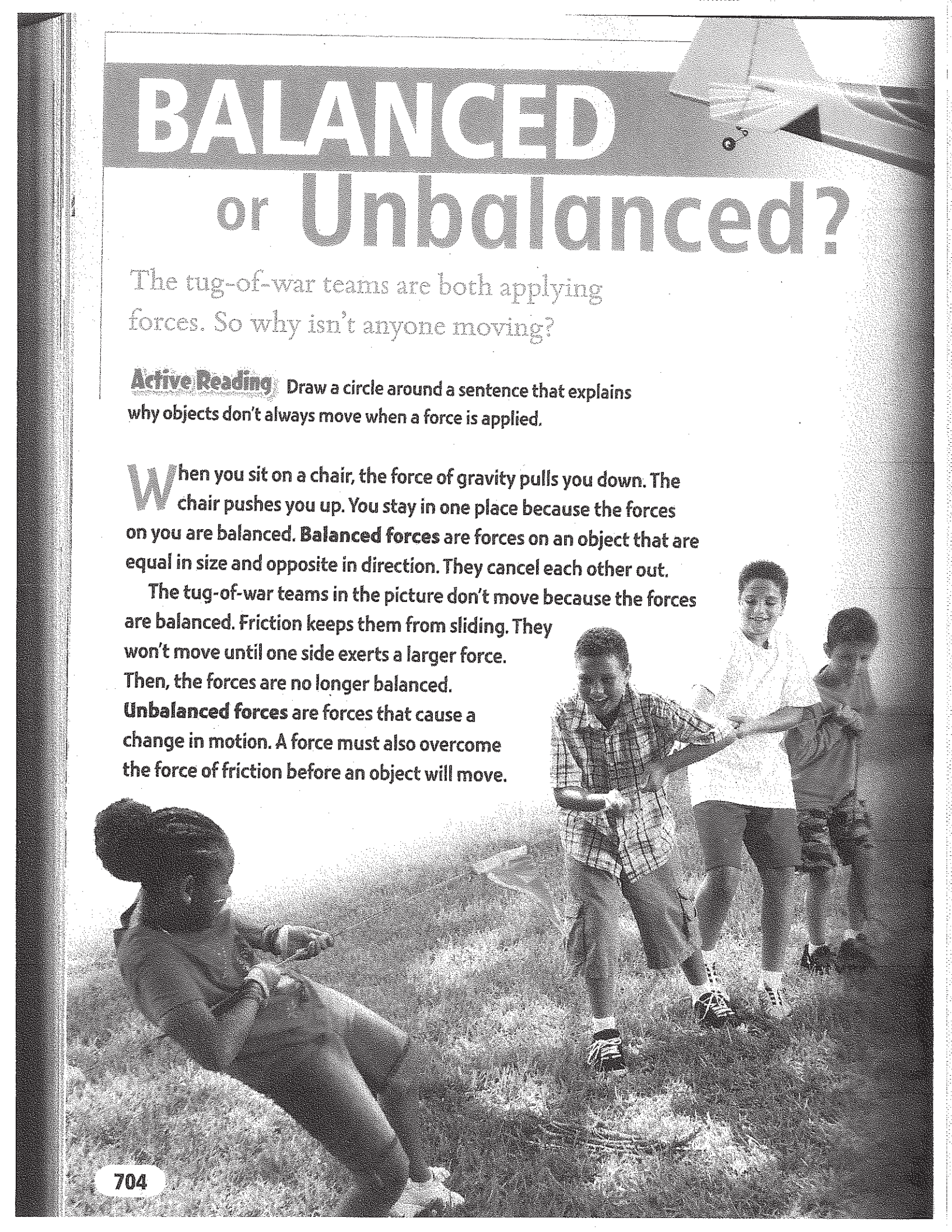
BALANCED or Unbalanced?

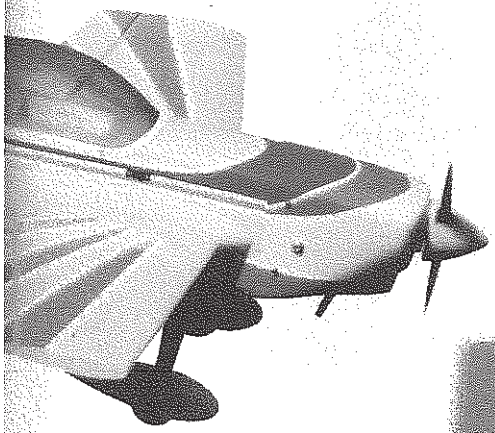
The tug-of-war teams are both applying forces. So why isn't anyone moving?

Active Reading Draw a circle around a sentence that explains why objects don't always move when a force is applied.

When you sit on a chair, the force of gravity pulls you down. The chair pushes you up. You stay in one place because the forces on you are balanced. **Balanced forces** are forces on an object that are equal in size and opposite in direction. They cancel each other out.

The tug-of-war teams in the picture don't move because the forces are balanced. Friction keeps them from sliding. They won't move until one side exerts a larger force. Then, the forces are no longer balanced. **Unbalanced forces** are forces that cause a change in motion. A force must also overcome the force of friction before an object will move.





When a plane flies at a constant velocity, all the forces on the plane are balanced. If they weren't, the plane would speed up, slow down, or gain or lose altitude.

The push on the first domino was a(n) _____ force that caused it to fall into the next domino. As each domino fell, it transferred the force to the next domino.

The force exerted on this domino by the falling dominoes is balanced by the force of the box. Because the forces are _____ the domino doesn't fall.

▶ Are there any forces acting on the dominoes that have fallen? If so, are they balanced or unbalanced? How do you know?

_____

_____

_____

_____

The forces on the dominoes are _____ when they are standing upright. When a falling domino hits them, the forces become _____ and they fall.

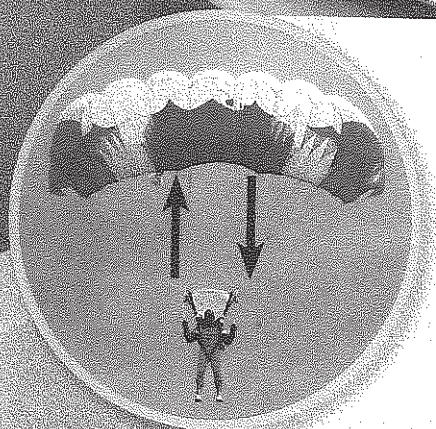
Contact Forces

Car mechanics use forces to lift tires and pull tool carts. These forces cannot act unless the mechanic touches the object to be moved. The object may be touched directly with a hand or using a handle or a rope, but there must be contact. A force that requires two pieces of matter to touch is called a **contact force.** You exert a contact force when you push or pull a piece of furniture.

One kind of contact force is friction. **Friction** is the force that results when two materials rub against each other or when their contact prevents sliding. Friction makes it harder for one surface to move past another. The amount of friction between two objects may depend on their texture, shape, speed, and weight. It may also depend on whether or not the surfaces are wet.

Solids are not the only materials that can cause friction. Air and water also resist motion when an object pushes against them. Air resistance is a type of friction that is present when particles of air contact a surface. Water causes a similar type of friction. Submarines and ships are designed with shapes that help them reduce friction and move through water easily.

3. CHALLENGE Why do you think mechanics need to change tires during races?



The smooth, compact shape of race cars reduces air resistance so that the cars can go fast. By contrast, the wide area of an open parachute increases air resistance, slowing the fall.

2. **Circle** the arrow that shows the direction of air resistance on the parachute.

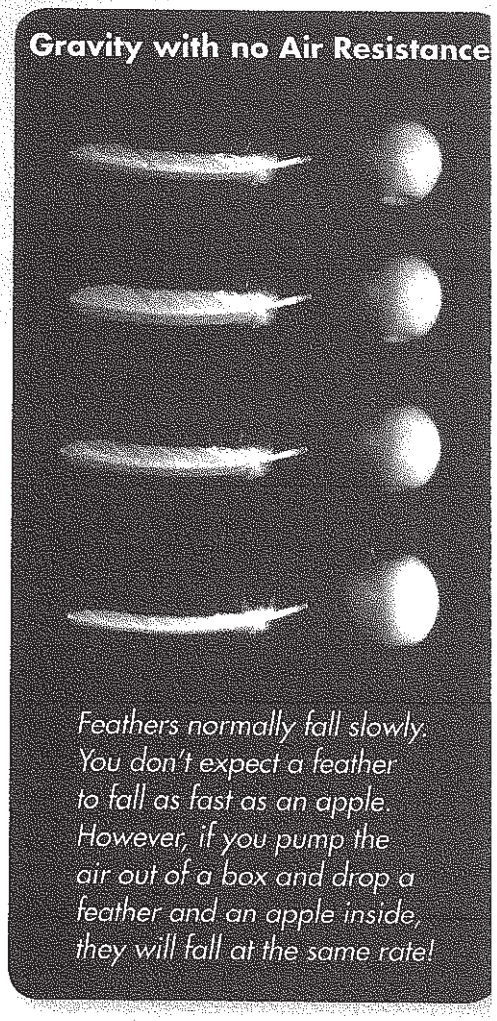
Non-Contact Forces

For friction to work, two things need to touch. There has to be contact between two surfaces, or contact with a gas or a liquid. But there are forces that can act at a distance. They work even if the object that is pushing or pulling is not touching the object being pushed or pulled! A force that acts at a distance is called a **non-contact force.** Three examples of non-contact forces are gravity, electric forces, and magnetic forces.

Gravity

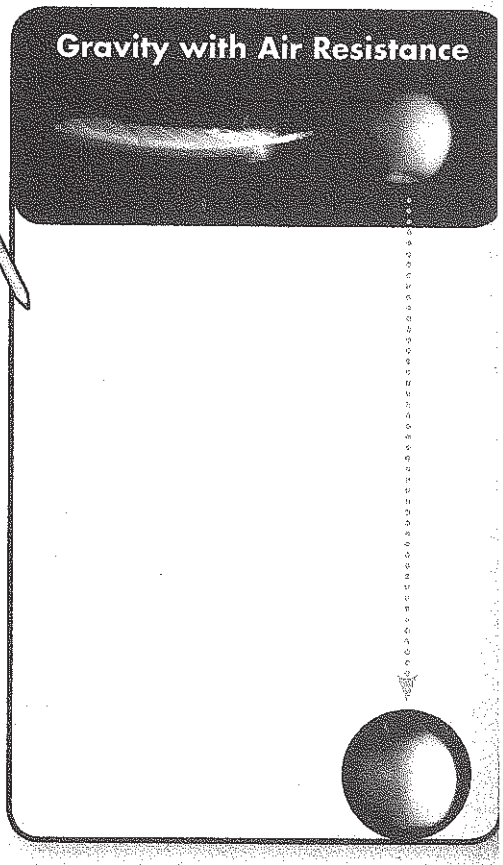
Every object in the universe exerts a pull on every other object. This force of attraction between any two objects is called **gravity.** Only the gravity of a large object such as Earth is strong enough to cause effects that we can notice easily. Without gravity, things would not fall. Gravity pulls objects toward Earth's center without touching them.

The weight of an object is just the force of Earth's pull on that object. As an object moves away from Earth, the object weighs less and less because the pull of Earth's gravity becomes weaker and weaker with distance.



Feathers normally fall slowly. You don't expect a feather to fall as fast as an apple. However, if you pump the air out of a box and drop a feather and an apple inside, they will fall at the same rate!

5. CHALLENGE Draw in the box at the right where you think the feather will be by the time the apple has hit the bottom of the box.



At-Home Lab

Does Gravity Affect You?

Stand. Stretch your left arm overhead. Leave your right arm at your side. Wait for 1 minute. Then compare the color of the palms of your hands. Share what you notice.

PULL (or Push) Harder!

Would you expect a bunt in baseball to go out of the park? Why or why not?

Active Reading As you read, circle the sentences that explain the relationship between the size of a force and motion.

▶ Use forces to explain why the boy can't ring the bell.

_____

_____

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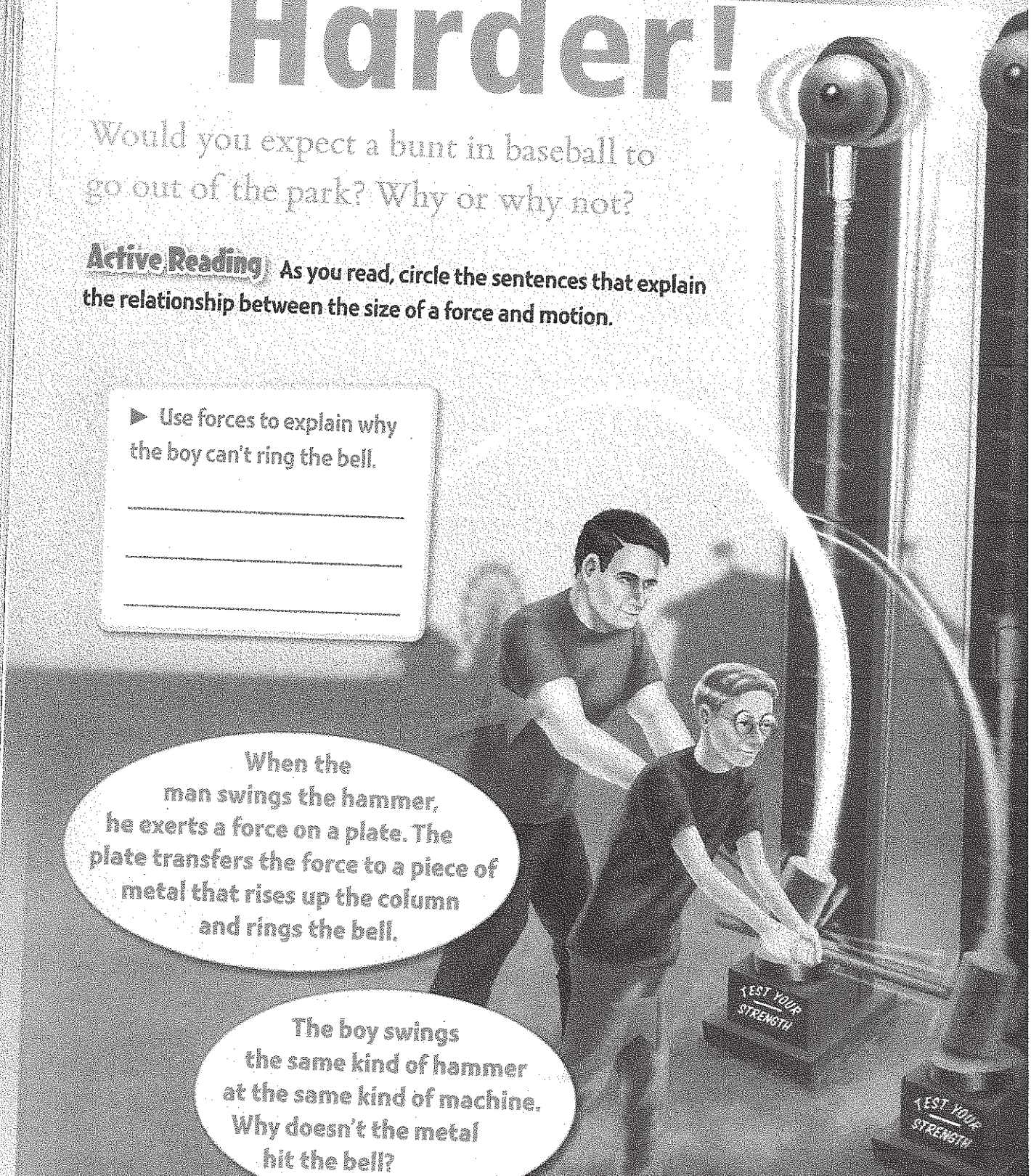
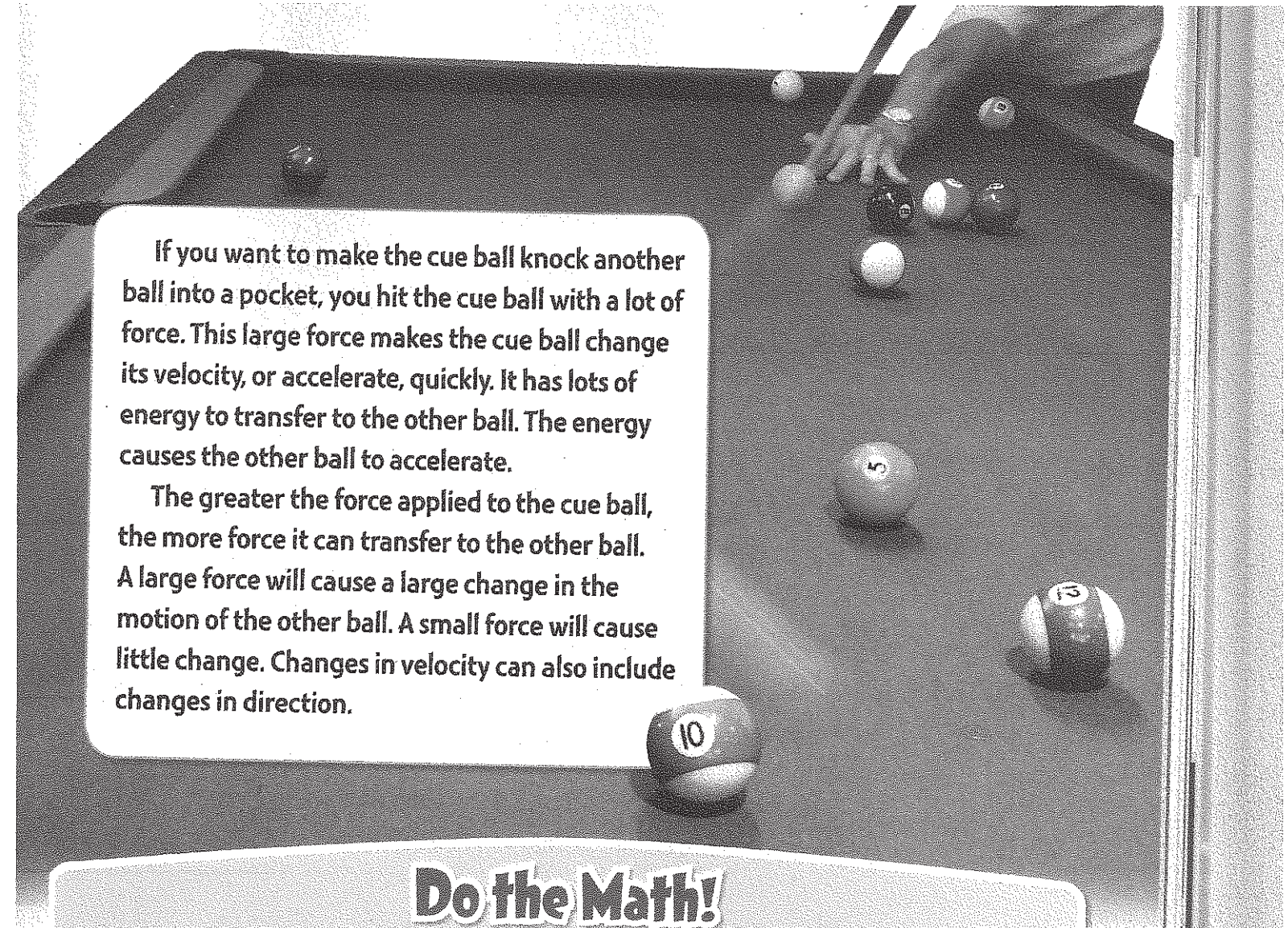




If you want to make the cue ball knock another ball into a pocket, you hit the cue ball with a lot of force. This large force makes the cue ball change its velocity, or accelerate, quickly. It has lots of energy to transfer to the other ball. The energy causes the other ball to accelerate.

The greater the force applied to the cue ball, the more force it can transfer to the other ball. A large force will cause a large change in the motion of the other ball. A small force will cause little change. Changes in velocity can also include changes in direction.

Do the Math!

Display Data in a Graph

Use the data in the table to make a graph that shows the relationship between the force applied to an object and its acceleration.

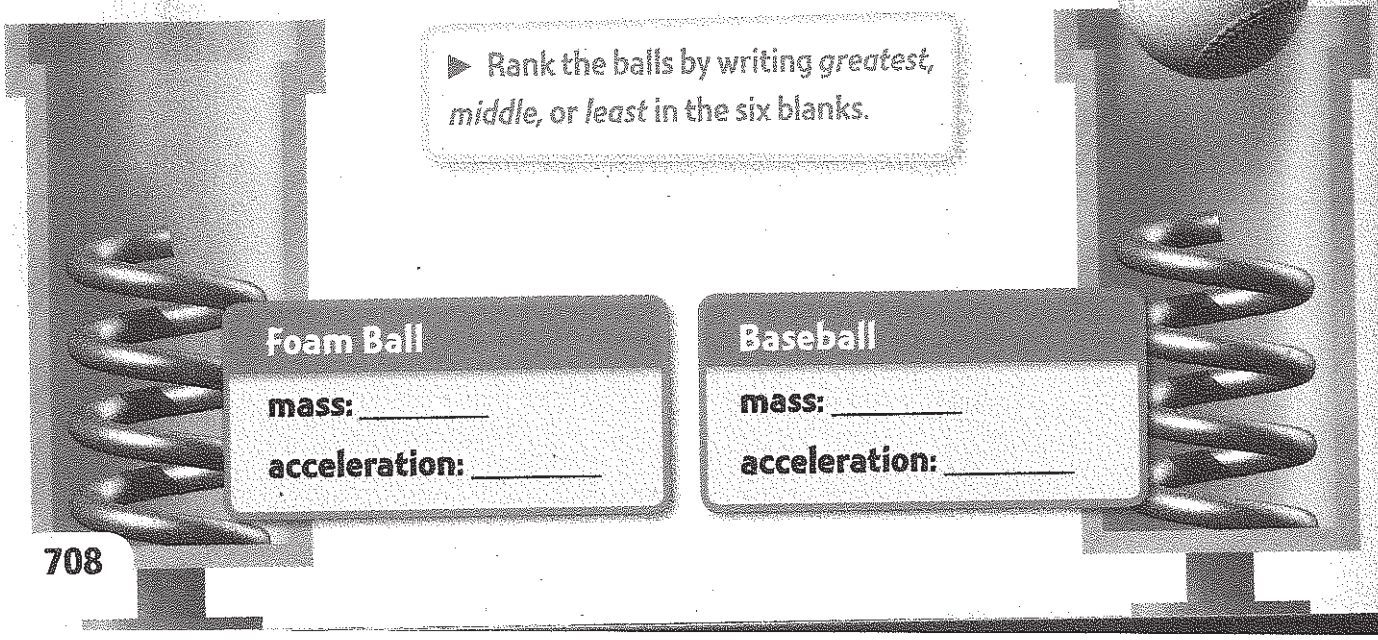
Force (N)	Acceleration (m/sec^2)
1	0.5
2	1.0
5	2.5
8	4.0
10	5.0

I'M NOT Moving!

It's easy to lift your empty backpack off the ground. Could you use the same force to lift it when it's full of books?

Active Reading As you read these pages, circle cause-and-effect signal words, such as *because, so,* or *therefore.*

The springs in the pictures all exert the same force on the balls, causing them to roll across the page. The ball with the least mass accelerates the fastest. Therefore, it travels the farthest. The same force has a greater effect on an object with a small mass than an object with a larger mass.



▶ Rank the balls by writing *greatest, middle,* or *least* in the six blanks.

Foam Ball	Baseball
mass: _____	mass: _____
acceleration: _____	acceleration: _____

I will know that a given object will have more change of motion with a large force. I will know that a given force will cause more change of motion on small masses.

Words to Know

acceleration
inertia

Changes in Motion

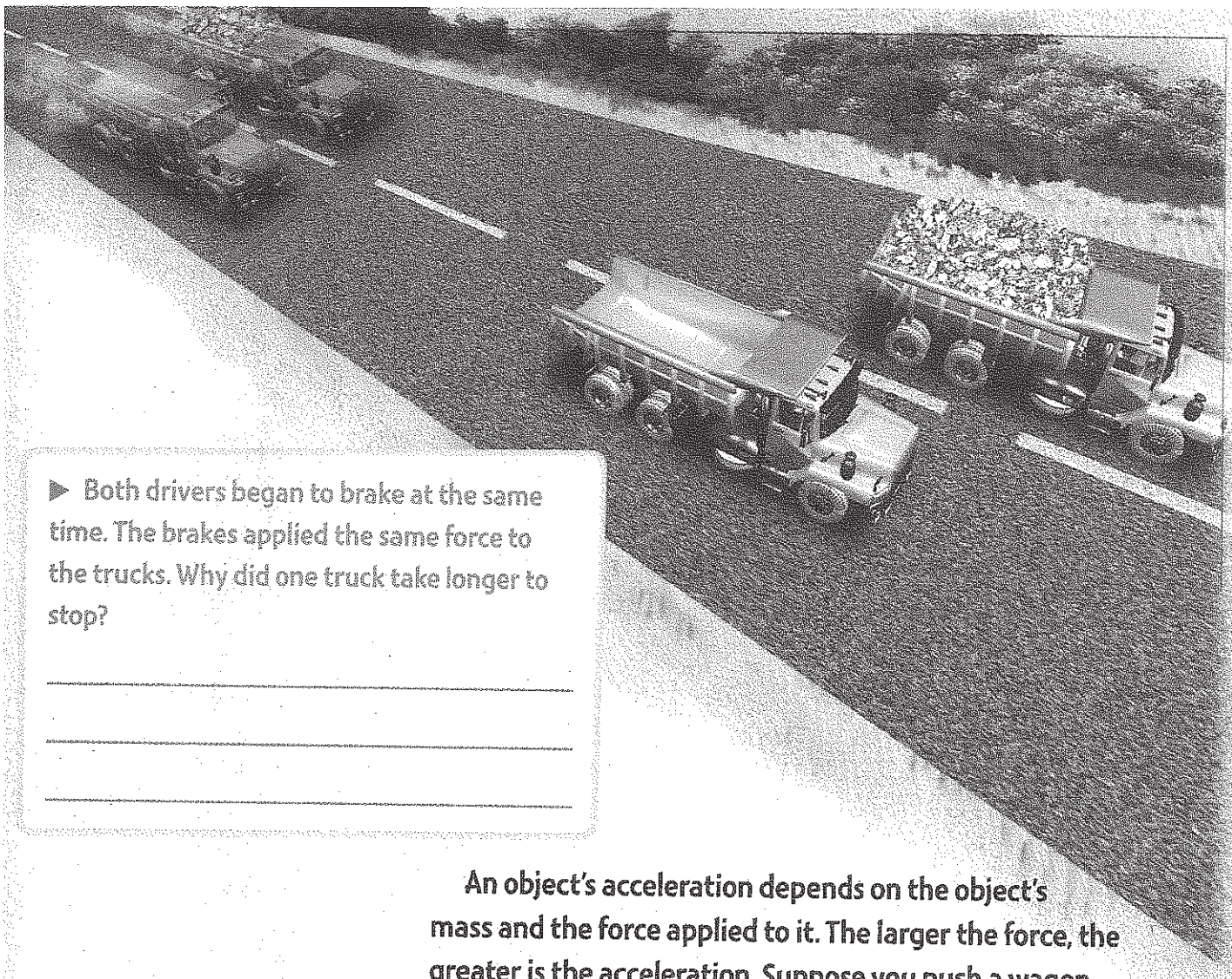
Have you ever observed the motion of a car? When the car approaches a red light, the driver steps on the brake pedal. The speed of the car drops to zero. When the light turns green, the driver steps on the gas pedal. The speed climbs from zero. If the car has to turn a corner, the driver turns the steering wheel. The car changes direction.

When an object speeds up, slows down, or changes direction, its motion changes. The rate at which the speed or the direction of motion of an object changes over time is its **acceleration.**

When we speak of acceleration, we usually mean going faster and faster, but in science the word *acceleration* means *any* change in motion. For example, the circular motion of a Ferris wheel is accelerated. Even if the wheel turns with constant speed, the riders change direction all the time. They go up, then forward, then down, and then backward.

An object has no acceleration if it moves in a straight line without changing its speed or direction, or if it is not moving at all. Motion without acceleration is called uniform motion. The word *uniform* tells us that the motion does not change. A train traveling at a steady speed on a straight track has uniform motion. A book sitting on a table also has uniform motion. Its speed is zero.

1. Explain What kind of motion do the people on the escalator below have? Why?



▶ Both drivers began to brake at the same time. The brakes applied the same force to the trucks. Why did one truck take longer to stop?

_____

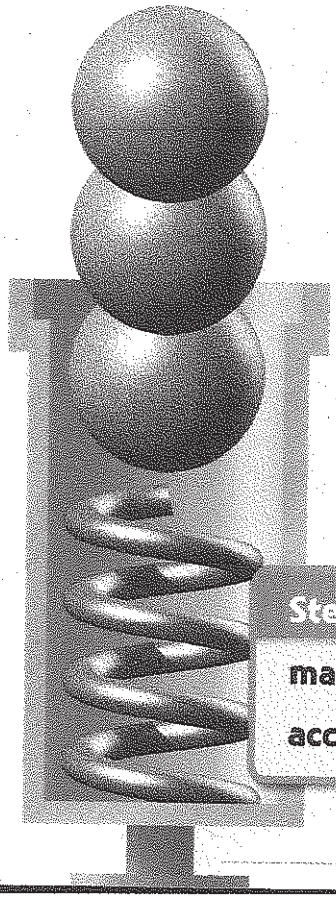
_____

_____

An object's acceleration depends on the object's mass and the force applied to it. The larger the force, the greater is the acceleration. Suppose you push a wagon gently. The wagon speeds up slowly. If you use more strength to push, then the wagon's speed changes quickly.

The less an object's mass is, the less force is needed to change its motion. It's easier to push an empty shopping cart than a full one. Light cars are used in drag races because a car with less mass speeds up faster than a car with more mass.

If you want to slide a heavy box across the floor faster, you have two options. You could take some items out of the box, which decreases its mass. Or you could have a friend help you, which increases the force you apply.



Steel Ball

mass: _____

acceleration: _____