chapter 9

NATURAL LAWS AND CAR CONTROL

KEY IDEA

How do the laws of motion affect your ability to control your vehicle?

YOU'RE THE DRIVER

If you had been the driver of this car and were using your safety belt, an air bag would have helped to protect you from serious injury. To be a safe driver, you need to know about the laws of motion. How do these natural laws affect your ability to control your car and help you drive safely?

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lesson 9.1
GRAVITY AND ENERGY OF MOTION

OBJECTIVES

- Describe how inertia affects your vehicle while going straight and while driving through a curve.
- Define momentum.
- Identify the factors that affect energy of motion.
- Explain how gravity affects your vehicle.

VOCABULARY

- inertia
- momentum
- energy of motion
- gravity

The motion of your vehicle is subject to the natural laws of motion. These laws include inertia, momentum, energy of motion, and gravity. In emergency situations, these natural laws can work for or against you.

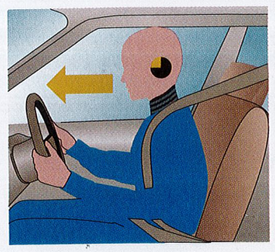
Inertia, Momentum, and Energy of Motion

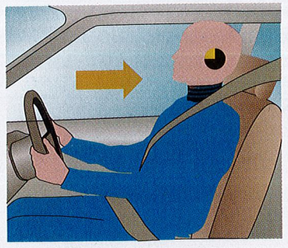
Objects that are at rest tend to stay at rest and objects that are moving tend to keep moving. This is the law of **inertia**. Inertia keeps a parked car at rest. For the car to move, it must be acted upon by forces produced by the engine. Once the car is moving, inertia causes the car and everything in it to continue moving in a straight line at a constant speed until acted upon by another force. **FIGURE 1** shows three examples of how inertia affects passengers in cars.

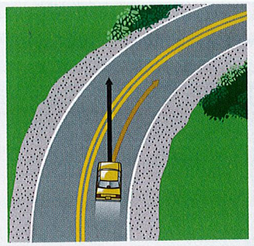
You can feel inertia when a car brakes rapidly. The force of friction on the brakes causes the car to slow down. But as the car slows down, inertia causes your body to continue to move forward. You feel this inertia as you are pressed against your safety belt. If you were not wearing a safety belt, your body would continue to move forward until it was stopped by the dashboard or the windshield.

You also experience inertia when a car accelerates rapidly. As the car accelerates, you seem to be pushed back into your seat. But no force is pushing you back. Instead, your body continues to move at the old speed, while the car speeds up.

FIGURE 1
Vehicle weight and speed determine how much inertia is generated.


As car decelerates


As car accelerates


Around a curve

You also experience inertia when a car drives around a sharp curve. You feel as if you are being pulled toward the outside of the curve because inertia causes your body to continue in a straight line.

Momentum is the tendency of an object to stay in motion, or the inertia of an object in motion. The amount of momentum depends upon the object's weight and speed. Heavy vehicles have more momentum than light vehicles moving at the same speed. A fast car has more momentum than a slow car.

A moving object also has **energy of motion**, or kinetic energy. A vehicle's energy of motion changes in proportion to the weight of the vehicle. The more a vehicle weighs, the greater its energy of motion.

A vehicle's energy of motion is proportional to the *square* of its speed. If you double your speed, your vehicle will have *four times* as much energy of motion and will need *four times* as much distance to stop.

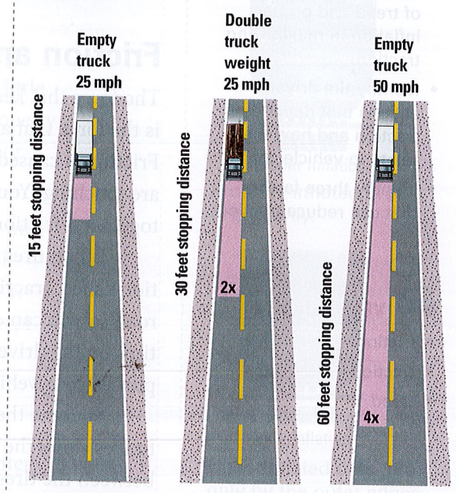
Gravity

Gravity is the force that pulls all things to Earth. Gravity also acts on you and your car.

The pull of gravity affects you as you drive up and down hills. When you drive uphill, the pull of gravity will cause you to lose speed.

When going downhill, gravity's pull will make you go faster. To control your speed, ease up on the accelerator and brake early. On a long downhill stretch, shift to a lower gear so the engine can slow the vehicle.

FIGURE 2



A vehicle's energy of motion increases with weight and speed.

review it 9.1

1. How does inertia affect your vehicle and passengers?

Critical Thinking

2. **Relate Cause and Effect** Which would cause a greater change in energy of motion: doubling the weight of a vehicle or doubling its speed? Why?

IN THE PASSENGER SEAT **Laws of Motion** As a passenger, pay attention to situations in which the vehicle accelerates, slows down, and enters a curve. Record the effects you feel in the passenger seat under these conditions. Write a paragraph describing your findings.

son 9.2
AND TRACTION

ECTIVES

how traction your car.

the importance and proper in maximizing

the driver that depend on and how they vehicle control.

three factors reduce traction.

ABULARY

How do you control your vehicle? Certainly the steering wheel, accelerator, and brake pedal are important. But you may be surprised to learn that your tires are a key part of your control system. The way your tires interact with the surface of the road is essential to safe driving.

Friction and Traction

The force that keeps a tire from sliding on the road is friction. **Friction** is the force that acts between materials as they move past each other. Friction is caused by tiny irregularities on the surface of the objects that are touching. You can feel the force of friction by rubbing your hands together—friction makes your hands get warmer.

When tires roll over the surface of the road, they create a form of friction called **traction**. Traction makes it possible for your vehicle to grip the road so you can control speed and direction. Press the accelerator and the tires on the drive wheels rotate. The traction of the tires on the roadway pushes your vehicle forward.

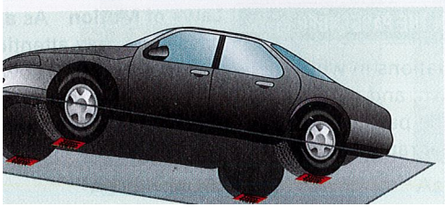
Squeeze the brake pedal and the friction of the linings against the brakes slows the four wheels. As the tires on these wheels slow, traction between the tires and road will slow your vehicle. Traction also enables your vehicle to turn left or right when the front wheels turn.

Tire Tread and Traction

The place where a tire touches the road is called its *footprint*. **FIGURE 3** shows each tire's footprint. Footprints are small—each is about the size of an adult's hand. These footprints are all you have for traction on the surface of the road.

The grooved surface of a tire is called **tread**. Tread provides the traction for starting, stopping, and gripping the road. This gripping action is critically important in preventing skids and hydroplaning. When the road is wet, water flows through the grooves in the tread and away from the tire, allowing the tire to grip the road.

footprints of your tires on the road are the act between your car and the road.



A tire's ability to grip the road increases as the amount of tread touching the road increases. Tire size also affects the amount of tread and traction on the road. Use care when putting larger tires on a vehicle because they alter the performance characteristics of the vehicle. Check the owner's manual for your vehicle for the maximum recommended size of tire.

Inflation and Traction

Properly inflated tires can mean the difference between keeping or losing control. **FIGURE 4** shows how too much or too little pressure can change the amount of tread on the road. A properly inflated tire will grip the road better than an underinflated or overinflated tire.

Underinflation When you drive on an underinflated tire, only the tire's outer edges provide traction. The outside edges will wear out first, shortening the life of the tire. In an emergency, the underinflated tire will not perform properly—it will accept less stress before losing its grip on the pavement. An underinflated tire is likely to heat up and fail more quickly than a properly inflated tire.

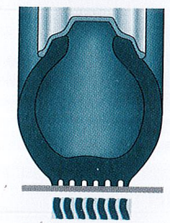
Overinflation If a tire has too much pressure, only the center of the tread will grip the road. The footprint will be smaller, so the tire will have less traction. Over time, the overinflated tire will wear out its center tread more quickly than a properly inflated tire.

Temperature Weather can change the pressure in your tires. If the air gets colder, tire pressure will drop. Your tires may become underinflated in cold weather. Hot temperatures will increase pressure, and may cause overinflation.

Check your tires' pressure on a regular basis to make sure they have the right amount of air. To assure an accurate reading, check tire pressure when your tires are cold, before you start driving.

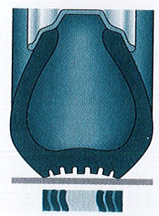
FIGURE 4

Too much or too little pressure can change the amount of tread, or footprint, on the road.



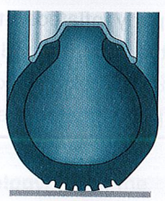
Proper Inflation

Properly inflated tires grip evenly.



Underinflation

Underinflated tires grip only by the outer edges.



Overinflation

Overinflated tires grip only in the center.

Using Traction

When you drive, you use traction to accelerate, brake, and steer. Even under ideal conditions, your tires provide a limited amount of traction.

If you release the accelerator and brake hard, braking may consume most of your traction, while acceleration may consume little. In an emergency situation, all your traction might be consumed by hard braking and steering, leaving no reserve traction. If the steering and braking requirements of traction exceed the amount available, the vehicle will skid and you may lose control. Always try to regain traction by adjusting your braking and steering force.

Here is an example of changing traction forces. You enter a curve at 55 mph. As you reach the middle of the curve, you realize you are going too fast, so you quickly brake and turn the wheel sharply into the curve. Braking and steering require far more traction than is available. In this situation, you would lose control of your vehicle.

How could you have managed your traction to remain in control? By using IPDE and searching at least 12–15 seconds ahead, you could have identified the curve and reduced your speed before entering the curve. At a slower speed, the hard braking and steering would have been unnecessary and the traction capability would have been sufficient to maintain control.

Many vehicles today have four-wheel or all-wheel drive. That means all four wheels have pulling power. Traction control devices are available on most new vehicles, and will be covered in more detail in Chapter 17.

YOU KNOW?

Pressure You
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erly inflated. A tire
is underinflated by
can look just like a
erly inflated tire.

Ensuring Good Traction

Three things are required to achieve ideal levels of traction. First, your vehicle must be in good condition. Second, the road surface must be smooth and clear. Finally, your actions must maximize traction.

Vehicle Condition A new vehicle is easy to control. But as a vehicle ages, you need to work hard to maintain it properly. If you allow tires, shock absorbers, or parts of the steering system to wear, traction and control will be reduced.

Tires are your lifeline to traction, so it is important to keep them in good condition. Check their pressure and inspect their tread regularly. Replace older tires before they are worn out. A worn, bald tire is dangerous and will not grip a wet or icy road. Because it has no tread, the tire can easily be punctured. If this happens, the tire could suffer a **blowout**, when all of the air escapes at once.

Good shock absorbers, or "shocks," are essential for maintaining traction. Worn shock absorbers will cause your tires to bounce on a rough road, leaving you with less traction. Replace worn shock absorbers to maximize control.

Road Condition When you drive on a dry, flat road with good tires, your traction is excellent. But your traction will be reduced when that same road is covered with rain or snow. Your traction is also reduced when you drive on gravel roads, or roads covered with sand, leaves, or oil.

Icy weather can be especially dangerous for driving. Ice can reduce traction so much that you may lose steering, braking, or acceleration control. Be alert that water will freeze in shaded areas and on bridges before it does on regular roads.

When you see the road condition is about to change, reduce your speed before you reach the area of reduced traction. To check how much traction you have, brake gently to see how your vehicle responds. If your vehicle does not slow or if your antilock brakes start to work, reduce your speed even more.

Driver Action Your actions affect your ability to manage traction. Quick turns and excessive speed, especially in a turn, can consume a great deal of traction. So can hard braking in a curve or on a slippery surface. Maximize your traction by steering, accelerating, and braking gently and smoothly. Lesson 3 will give you more information about how to maintain control of your vehicle.

review it 9.2

1. Explain why friction is important in controlling your vehicle.
2. What three actions consume traction? Why is it wise to never exceed traction capability?
3. What steps can you take to ensure that an older car will have good traction?

Critical Thinking

4. **Apply Concepts** How do overinflated and underinflated tires affect traction?

IN YOUR COMMUNITY

Use Technology With the owners' permission, examine the tires of at least 10 vehicles. Check for signs of worn tread or bald spots. Use a tire-pressure gauge to determine the tire pressure of each of the vehicles. Record your findings. Then write a brief report that includes the percentage of vehicles with overinflated or underinflated tires, and worn or bald tread.

lesson 9.3

VEHICLE BALANCE AND CONTROL IN CURVES

OBJECTIVES

- Define center of gravity.
- Identify the key factors that can affect a vehicle's balance.
- Describe how speed, the sharpness of the curve, vehicle load, and road shape affect control in a curve.

VOCABULARY

- vehicle balance
- center of gravity
- pitch

Vehicles of different sizes and shapes handle differently. Small vehicles are light and can accelerate quickly. Sports cars are low to the ground and handle well in curves. Vans and SUVs can be unstable on steep slopes. What makes some vehicles more difficult to control than others?

Vehicle Balance

Your ability to control your vehicle is affected by its balance. **Vehicle balance** is the distribution of a vehicle's weight on its tires as they contact the ground. The only time a vehicle is in perfect balance is when it is not moving. Whenever a vehicle accelerates, brakes, or turns, the changing weight on each tire affects its balance.

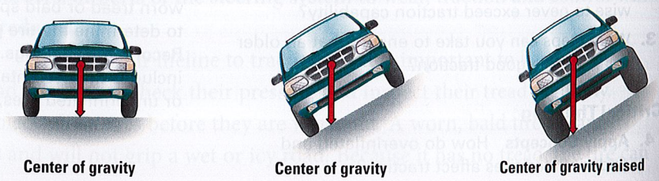
Center of Gravity The point around which an object's weight is evenly distributed is called its **center of gravity**. The center of gravity is the balance point. If you could balance the car on your finger, your finger would be directly under the center of gravity.

For a perfectly symmetrical object, such as a bowling ball, the center of gravity is exactly at the center of the object. But the weight of a car is not evenly distributed throughout the car's body. The chassis weighs more than the roof. The front end with the engine weighs more than the back end. So the center of gravity is not in the center of the vehicle, but closer to the wheels and more toward the front.

Stability A vehicle with a center of gravity that is close to the ground is more stable and less likely to roll over than one with a high center of gravity. Passenger cars typically have a low center of gravity. Taller, narrower vehicles such as SUVs, pickups, and vans have a higher center of gravity and tend to be less stable.

Installing large tires or carrying heavy cargo can raise a vehicle's center of gravity. This can have a significant impact on vehicle control if a vehicle's center of gravity is already high.

FIGURE 5
A vehicle's stability decreases as its center of gravity rises.



Balance and Steering

Maneuvers that shift weight to different areas of the vehicle cause changes to the vehicle's balance. Sudden weight shifts can throw a vehicle out of balance, sometimes with deadly consequences.

To understand the motion of your vehicle, it is useful to imagine three axes crossing at the center of gravity. Your vehicle may rotate around these axes in three ways: pitch, roll, and yaw.

Pitch A tilting motion from front to back is called **pitch**. When you apply the brakes, the motion shifts more weight onto the front tires and less on the rear tires. When you accelerate, more weight is put on the rear tires and less weight on the front tires. This changing weight on your tires can increase or reduce traction.

If you brake too hard, your front tires may slide, or skid. The loss of traction in the front will result in a loss of steering control. To correct this, lift your foot off the accelerator. Do not apply the brakes. Look and steer to the target area to regain steering control.

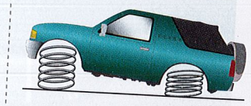
Roll A vehicle may also tip to the side, or roll. Strong or sudden acceleration, braking, or turning can cause a vehicle to roll over. The greater your speed and the harder you steer, the greater the risk of rolling. Reduce speed and steer smoothly, using only the amount of steering needed to make your maneuver.

Yaw Your vehicle may rotate clockwise or counterclockwise, or yaw. When the rear tires lose traction, a vehicle may yaw. In extreme cases, a vehicle may spin completely around.

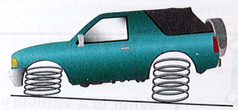
Forces in Curves

Inertia and traction work on your vehicle as you drive through a curve. Your ability to control your vehicle in a curve is affected by the sharpness of the curve, the speed and weight of your vehicle, and the shape of the roadway.

FIGURE 6
Pitch force is in effect when a vehicle's front or back end rises or falls. A vehicle can pitch due to rapid acceleration or braking.



During rapid acceleration, the vehicle's weight pitches to the rear.



During hard braking, the vehicle's weight pitches to the front.

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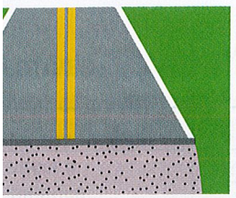

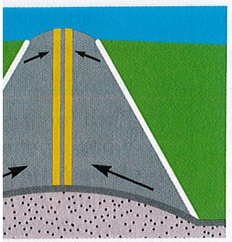

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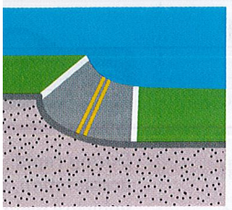

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Sharpness of Curve The sharper the curve, the more traction your tires need to grip the road in order to overcome inertia.

Speed The momentum of your vehicle increases with speed. The faster you go, the more traction you need to overcome your momentum. If you go too fast, your vehicle may not be able make the turn.

Load Carrying a heavy load, such as passengers and cargo, changes the center of gravity, which alters the weight distribution on the wheels and affects how the vehicle handles. To maintain control, reduce speed when you are heavily loaded.

Shape of the Road The shape of the roadway affects your ability to control your car. **FIGURE 7** shows three different types of road surfaces. Many roads are level. Other roads have a crowned surface. The crowned surface helps rainfall drain from the roadway and prevents flooding. However, it is more difficult to maintain traction if a curve has a crowned surface. Gravity will tend to pull your vehicle to the side of the roadway.

Some roadways are banked, or tilted so one side is higher than the other. A curve that is higher on the outside than it is on the inside is called a banked curve. When you drive around a banked curve, the force of gravity pulls you downward and into the curve. This helps you overcome inertia.

view it 9.3

at is a vehicle's center of gravity?

cribe three ways that a vehicle may move
und its center of gravity.

four factors that can affect your control as
drive around a curve.

Thinking

ate Cause and Effect You are in a pickup truck
n a full load of lumber. How will this load affect your vehicle's center of gravity? Why is it important to know this?

IN YOUR COMMUNITY **Dangerous Curves** With a team of classmates, locate several curves in your community that have reduced-speed warning signs. Record the street's name, the legal speed limit before the curve, and the reduced speed limit indicated for the curve. Present a report to your classmates with your judgment as to why the speed for the curve is reduced.

lesson 9.4
STOPPING DISTANCE

When you have to stop quickly, you must do three things. You must perceive the hazard in your path of travel, react, and brake to a safe stop.

OBJECTIVES

- Describe the three actions that determine total stopping distance.
- Identify key factors that affect braking distance.

VOCABULARY

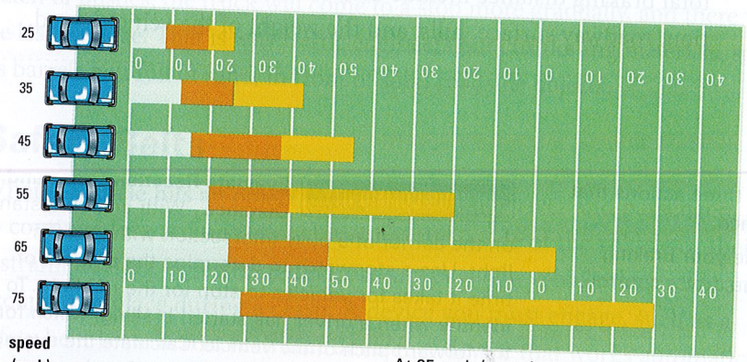
- total stopping distance
- perception time
- perception distance
- reaction time
- reaction distance
- braking distance

Total Stopping Distance

The distance your car travels from the time you first perceive a hazard until you reach a full stop is your **total stopping distance**. You should always be able to stop within the distance you can see ahead. Refer to **FIGURE 8** as you read how the time required to perform each of the three actions determines total stopping distance. Notice that it will take you almost 300 feet, or the length of a football field, to stop if you are traveling at 65 mph.

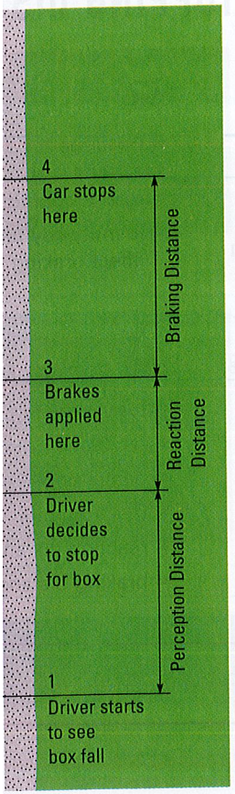
Perception Time and Distance The length of time it takes you to identify a hazard, predict a conflict, and decide to brake is your **perception time**. Perception time for alert drivers is about three fourths of a second. The distance your vehicle travels during your perception time is your **perception distance**.

FIGURE 8
Total stopping distance is based on good brakes and tires on dry, level concrete pavement.



At 25 mph (rounded to the nearest number)	
Perception time = 1.1 x speed	28 ft or 9 yd
Reaction time = 1.1 speed	28 ft or 9 yd
Braking distance = speed^2 x 0.039	25 ft or 8 yd
Total stopping distance	81 ft or 27 yd

PPING DISTANCE



Perception time varies greatly, depending upon visibility, your alertness, and your line of sight. Sometimes it takes longer to perceive a complex driving situation than to brake to a stop. You can improve your perception time by using IPDE and knowing when and where to search for potential hazards. Always search at least 12–15 seconds ahead.

Reaction Time and Distance Once you identify a hazard, the length of time you take to apply the brake is your **reaction time**. An alert driver's reaction time is about three fourths of a second. The distance your vehicle travels while you react is called your **reaction distance**.

Braking Distance The distance your vehicle travels from the time you apply the brake until you stop is your **braking distance**. In order to stop, your brakes must overcome your energy of motion. Braking distance is proportional to the square of your speed. If you were traveling at 40 mph, your braking distance would be four times longer than if you were traveling at 20 mph.

Factors That Affect Braking Distance

The most efficient way to stop is in a straight line. This allows the braking force to be distributed to all four tires. But many factors can increase the distance it takes to stop. Factors that can affect total braking distance include driver ability, speed, vehicle condition, roadway surface, hills, and the weight of the vehicle's load.

view it 9.4

the order they occur, list the three actions that
etermine total stopping distance.

st six factors that can increase your braking
stance. Which of these can the driver control?

al Thinking

elate Cause and Effect What law of motion
ontrols stopping distance?

alculate Use Figure 8 and the calculation
rmulas to calculate total stopping distance for
peeds of 20, 30, 40, 50, 60, and 70 mph.

IN YOUR COMMUNITY **Evaluate Reaction Times and Distance** With an adult, stand on the corner of a busy intersection with a traffic light. Use a stopwatch to determine the amount of time it takes for vehicles to stop for the red light. To identify when a driver has started braking, watch for the forward pitch of the vehicle. Calculate the average reaction time and stopping distance of each car.

lesson 9.5

CONTROLLING FORCE OF IMPACT

If you have seen a traffic collision, you know that it can happen in the blink of an eye. Collisions can be violent, but if you know how to protect yourself and your passengers, you can reduce the risk of injury.

OBJECTIVES

- List three factors that affect the force of impact in a collision.
- Identify the proper use of safety belts.
- Describe how air bags have been improved and how to get the maximum benefit from air bags.
- Explain how child passengers can be protected.

VOCABULARY

- force of impact
- active restraint device
- passive restraint device

Force of Impact

The force with which a moving object hits another object is called **force of impact**. Three factors determine the force of impact—speed, weight, and the time between initial impact and stopping.

Speed A vehicle's momentum is proportional to its speed and weight. Any reduction in speed will reduce the damage inflicted. Always try to reduce speed in an emergency.

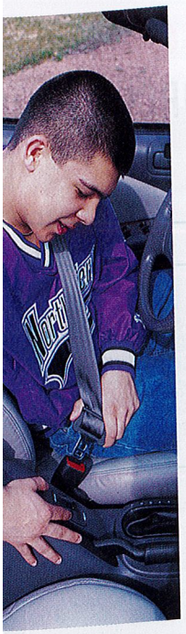
Weight The heavier a vehicle, the more damage it will cause in a collision. A vehicle weighing twice as much as another vehicle will hit a solid object twice as hard.

Time Between Impact and Stopping How quickly a vehicle stops affects the force of the impact. If a truck hits a stone wall, the force of impact is great because the collision occurs in a brief moment. But if the same truck hits a patch of bushes, the truck will come to a stop more gradually, and there will be less damage. That is why traffic engineers put cushioning materials, such as barrels half full of sand, in front of solid roadside objects.

Safety Belts

When a vehicle hits an object, inertia causes the driver and passengers to continue forward until they hit either the inside of the vehicle or their restraint devices. A restraint device is any part of a vehicle that holds an occupant in place during a crash. A device you must engage, such as a safety belt, is an **active restraint device**. A device that works automatically, such as an air bag, is a **passive restraint device**.

Wearing a safety belt is your first defense in an emergency. Safety belts hold you in place and prevent you from being thrown from the vehicle.



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During a crash, safety belts distribute the forces of rapid deceleration over larger and stronger parts of the body: the pelvis, chest, and shoulders.

A typical safety belt consists of a lap belt and a shoulder belt securely fastened to the vehicle's frame. Safety belt webbing is flexible, so it can stretch slightly during a collision. In a collision, the reels of the belt will suddenly tighten up and hold you in place.

Any time you are in a vehicle, you need to wear a safety belt. Make it a habit to check that all your passengers are buckled up, too. Follow these steps to maximize protection from your safety belt:

1. Adjust your seat back to an upright position and sit all the way back. Make sure your safety belt is not twisted.
2. Click the safety belt's latch into the buckle.
3. Adjust the lap portion of the safety belt so it is low and snug across your hips. The bottom portion of the belt should just touch your thighs. This adjustment will ensure that the crash forces are applied to your pelvic bones instead of your internal organs.
4. Adjust the shoulder belt snugly across your chest and collarbone.

You risk serious injury if you wear your shoulder belt under your arm or behind your back.

Air Bags

An air bag is a balloon-type device that automatically inflates to protect you. In a collision, air bags inflate, cushioning the force of impact as you are thrown forward. If a collision happens in the blink of an eye, air bags work even more quickly.

Frontal air bags Air bags that deploy only when there is a crash at the front of the vehicle are called frontal air bags. The first generation of air bags deployed so rapidly and powerfully that they were dangerous to some passengers.

Advanced frontal air bags have been required on all cars and light trucks since September 2006. Advanced frontal air bag systems have sensors that can detect the size and seat position of an occupant, whether the occupant is wearing a seat belt, and the severity of the crash. The airbag then deploys with the appropriate speed and intensity for the situation.

Side air bags Other air bags, called side air bags, are designed to protect your head and chest in a collision. Side impact air bags can protect occupants from injury and from ejection during a rollover.

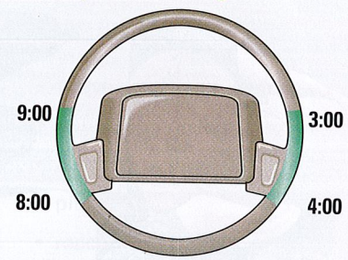
Using Air Bags Effectively Air bags are designed to work with safety belts. If you are not securely fastened into your safety belt when the bag deploys, you risk greater injury.

Keep your hands on the steering wheel between the 9:00 and 3:00 or 8:00 and 4:00 positions, as shown in **FIGURE 11**. This steering position also gives you the best control.

Adjust your seat so that your chest is at least 10 inches away from the hub of the steering wheel.

As a front seat passenger, move your seat as far back as possible. The passenger-side air bag is two to three times larger than the driver-side air bag and will deploy much farther out from the dashboard.

FIGURE 11
A balanced hand position will provide good steering control and avoid injury if the air bag deploys.



Child Passenger Safety

All states have laws that require proper restraints for infants and children traveling in vehicles. These laws are usually specific to the age and weight of the child.

Safety belts usually do not fit children until they are between 8 and 12 years old. Until then, children who have outgrown a car seat with a harness are safer in a booster seat.

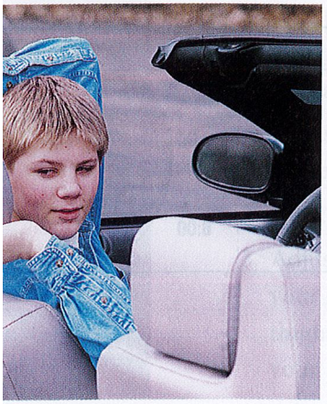
FIGURE 12
It's important to know the proper ways to install and use child safety-restraint seats.


Infants one year old or younger and weighing up to 20 pounds should be carried in a rear-facing car seat.


Children older than age one and more than 20 pounds should be carried in a forward-facing car seat.


All children younger than 13 years should sit or be carried in the back seat.

r head restraint to reach the
he back of your head.



Other Protective Devices

Along with safety belts and air bags, automobile manufacturers are making vehicles safer for all of us. Here are a few recent improvements:

- **Crush zones** The front and rear ends of vehicles are designed so that they will be crushed during a collision. As the front or rear end crumples, it absorbs much of the force, greatly reducing the impact on the driver and passengers.
- **Energy-absorbing bumpers** Bumpers are designed to absorb low levels of impact (under 5 mph) without damage.
- **Side-impact panels** Reinforced panels on the sides of a vehicle help absorb crash energy. Side panels also reduce the risk of objects penetrating the passenger compartment.
- **Penetration-resistant windshields** To protect against flying glass, vehicles now have windshields made with a thin layer of plastic between two layers of glass.
- **Head restraints** Padded headrests on the top of seats are designed to protect you against whiplash injuries. However, to get this protection, you must adjust your headrest to the proper head height, as shown in FIGURE 13.

iew it 9.5

e the three factors that affect the force of
act. Which of these can a driver control?

t four steps should you take to put on a
ty belt properly?

are driving a car with air bags. What are
e key steps you should take to protect
self?

is it important that children ride in the rear
of a car with proper safety equipment for
age and size?

Critical Thinking

5. **Apply Concepts** Why must automotive engineers understand physical laws when designing safer vehicles?

IN YOUR COMMUNITY **Seat Belt Laws** Compare your state's seat belt laws to six other states across the nation. How do the laws differ? Analyze what factors may cause states to have different seat belt laws. Write a report and share it with your class.

CHAPTER 9 REVIEW

Lesson Summaries

9.1 GRAVITY AND ENERGY OF MOTION

- Inertia is the tendency of an object to remain at rest, or to continue at the same speed and in the same direction, unless acted upon by another force.
- Momentum is a measure of inertia in motion; a vehicle's momentum depends upon its speed and weight.
- A vehicle's energy of motion, or kinetic energy, is proportional to its weight and to the square of its speed.
- Gravity affects driving up and down hills.

9.2 TIRES AND TRACTION

- Friction between tires and the surface of the road is called traction.
- To provide the most traction, tires must have good tread and be inflated properly.

9.3 VEHICLE BALANCE

- Every vehicle has a center of gravity that is affected by the vehicle's height and load.
- Control in curves is affected by speed, the sharpness of the curve, the shape of the roadway, and vehicle load.

9.4 STOPPING DISTANCE

- Total stopping distance includes perception distance, reaction distance, and braking distance.
- Braking distance is affected by the driver's ability to see and react; vehicle speed; condition of the vehicle and road surface; momentum; and vehicle load.

9.5 CONTROLLING FORCE OF IMPACT

- The force of impact is determined by a vehicle's speed and weight, and the time between impact and stopping.
- Proper use of restraint devices can protect against injury in collisions.

Chapter Vocabulary

- active restraint device
- blowout
- braking distance
- center of gravity
- energy of motion
- force of impact
- friction
- gravity
- inertia
- momentum
- passive restraint device
- perception distance
- perception time
- pitch
- reaction distance
- reaction time
- total stopping distance
- traction
- tread
- vehicle balance

Write the word or phrase from the list above that completes the sentence correctly.

1. The amount of time it takes to perceive something in your path of travel is known as _____.
2. The amount of time it takes to execute an action, such as applying the brakes, is _____.
3. The _____ is the point around which an object's weight is evenly distributed.
4. A motion in which a vehicle tilts from back to front is known as _____.
5. The friction between a tire and the surface of the road is called _____.
6. _____ is the force that pulls all things to Earth.