UNIT 6

The Physics of Fun

In this unit, you will

- read about the engineering behind the development of amusement park rides.
- review skimming and making predictions.
- increase your understanding of the target academic words for this unit.

READING SKILLS Making Inferences

Self-Assessment

Think about how well you know each target word, and check (✓) the appropriate column. I have...

TARGET WORDS (AWL)	never seen the word before	seen the word but am not sure what it means	seen the word and understand what it means	used the word, but am not sure if correctly	used the word confidently in *either* speaking *or* writing	used the word confidently in *both* speaking *and* writing
adult						
automate						
brief						
credit						
distort						
draft						
input						
obtain						
paragraph						
prior						
regulate						
revise						
tradition						
violate						

Outside the Reading What do you know about amusement parks? Watch the video on the student website to find out more.

Oxford 3000™ keywords

Before You Read

Read these questions. Discuss your answers in a small group.

1. Are you afraid of heights, or do you enjoy being up high? What is one experience you've had with visiting a high place?
2. What is your favorite amusement park ride? Describe why you like it and how it makes you feel.
3. What are some things that engineers need to think about when they build something that will hold people?

REVIEW A SKILL **Skimming and Making Predictions** (See p. 34)

Skim the article and make a prediction to answer the question. When you finish reading, check your prediction to see if it was correct. What is the main idea of this article?

Read

The following article from a popular science magazine tells the story of the first amusement ride.

A Whale of a Wheel

In 1889, France hosted the first *Exposition Universelle*, or World's Fair, in Paris. In every way, the Exposition was so big, so glamorous, so exotic that no one believed anything could ever surpass it. The city of Chicago, Illinois, decided to try.

The Chicago World's Fair was held in 1893, but planning and building started much sooner. The Fair's organizers wanted to show the world that the United States, and specifically Chicago, was just as capable of grand artistic and technological wonders as France. The centerpiece of the Paris Exposition was an elegant tower of steel tapering up to the sky. It was designed by Gustav Eiffel and gave daring visitors a view of Paris that took their breath away. The organizers of the Chicago World's Fair had to come up with something even more magnificent.

The Ferris wheel at the Chicago World's Fair

Finding a suitable design to rival the Eiffel Tower proved difficult. Architect Daniel H. Burnham was in charge of the project for the Chicago World's Fair. He received dozens of proposals from engineers and architects around the country to build various kinds of towers. One day, he received a **brief** proposal and rough **draft** of plans for something more unbelievable

and outrageous than any **prior** proposal. The author of this proposal was George Washington Gale Ferris Jr.

Ferris proposed building a gigantic wheel that people could ride on as it turned. Burnham rejected Ferris's proposal. He could not believe that such a thing could be safe. It must **violate** the laws of physics. Its own weight would surely **distort** the metal beams, causing it to turn irregularly and eventually collapse. Despite Burnham's fears, Ferris knew his design was sound. He knew that equal pressure applied to every spot on the wheel would balance the forces acting on it. Physics was on his side.

Ferris **revised** the proposal three times and drew up many more **drafts** of engineering plans. He added countless **paragraphs** of detailed explanation on the engineering required. He got other engineers to inspect his plans and confirm their soundness. Ferris finally **obtained** Burnham's approval in December 1892 and began construction immediately. Soon the wheel towered over the city. By opening day in May 1893, the Ferris wheel was already the star of the Chicago World's Fair.

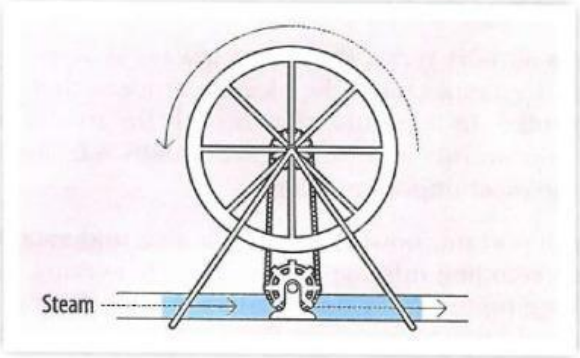
Robert Graves was a reporter for the newspaper, *The Allegbenian*. He visited the World's Fair and described the Ferris wheel for readers:

> What is the principle, the chief principle, on which the wheel is constructed? It is that of a bicycle wheel.... The lower half of the wheel simply hangs from the mighty axle [center bar], and this lower half supports the upper half by means of the steel framework of its two rims [sides].... The wheel, though apparently rigid in its construction, has just enough elasticity to make this method of support possible, and yet not enough elasticity to produce any appreciable trembling or slipping effect.

The wheel was supported by two 140-foot (43-meter) steel towers. The 45-foot (14-meter) axle was the largest single piece of forged steel at the time in the world. The wheel itself had a diameter of 250 feet (72 meters), a circumference of 825 feet (251 meters), and a maximum height of 264 feet (80 meters). Between the two rims of the wheel, Ferris hung 36 wooden carriages, like railroad cars, that could hold 60 people each. Every car hung from its own axle. This meant that the cars would swing slightly back and forth as the wheel slowly rotated, but they, and the people inside them, always stayed upright.

The Ferris wheel turned by the power of steam. Two huge boilers, located off the main fairgrounds, generated steam and kept it under high pressure. A system of underground pipes delivered the high-pressure steam to a large wheel on the ground under the Ferris wheel. The energy **input** from the steam caused the ground wheel to rotate, which drove the movement of the whole structure.

The ground wheel and the axle of the Ferris wheel were connected to each other by a massive chain that wrapped around them both. The ground wheel and the axle both had a band of raised pieces around them, called sprockets. The links of the chain fit over the sprockets and held the chain in place. As the steam from the boilers forced the ground wheel to rotate, the chain was pulled along the sprockets. This caused the axle above to rotate as well. The axle then turned the Ferris wheel. A series of brakes and other control devices **regulated** the energy **input** to keep the wheel's movement smooth and steady.



Steam forced the ground wheel to rotate, causing the Ferris wheel to turn.

Ferris was given **credit** for the success of the Chicago World's Fair. His wheel was not only a technological marvel, but a thing of beauty. In fact, the fair's organizers worried that Ferris might have done his job too well. The Ferris wheel seemed too light, too delicate to support itself. History records, however, that well over a million passengers rode the wheel during the Fair without incident.

The influence of Ferris's engineering and entertainment marvel is still clear today. In 1999, London, England, continued the **tradition** of marking momentous occasions by erecting a Ferris wheel. The London Eye, the largest Ferris wheel in the world, was built to celebrate the beginning of the new millennium. On a smaller scale, Ferris wheels of various sizes and types are attractions at fairs and amusement parks around the world. More than a century after it first dazzled visitors at the Chicago World's Fair, the Ferris wheel still has the power to fascinate, thrill, and amaze. ■

Reading Comprehension

Mark each sentence as *T* (true) or *F* (false) according to the information in Reading 1.

___ 1. The 1889 World's Fair in Paris hosted the first Ferris wheel.

___ 2. Daniel Burnham first rejected plans for the Ferris wheel because he thought it was unsafe.

___ 3. People in the Ferris wheel stayed upright as the wheel turned because the carriages they sat in were locked into place and did not move.

___ 4. A giant chain forced steam from the boilers into the ground wheel, which in turn caused the sprockets to rotate the axle. The axle then turned the Ferris wheel.

___ 5. Ferris wheels continue to be popular tourist attractions, as evidenced by the construction of the London Eye, the largest Ferris wheel in the world.

READING SKILL Making Inferences

LEARN

When authors write, they don't always state every idea that they want you to understand. Often, they leave out ideas that they think don't need to be explained. In literature, they do this for artistic reasons. In factual articles, like the ones in this unit, details are usually left out in order to keep the text focused on the most important points.

It is important, however, that you also understand the unstated ideas in a text. Understanding missing information by making guesses is called *inferring*, or making *inferences*. Good readers make inferences based on other ideas in the text and knowledge about the world. This leads to a fuller understanding of the author's ideas and intentions.

APPLY

Infer the answers to these questions. Then, on the line below, cite evidence from Reading 1 and explain how it supports your inference.

1. Before the Chicago world's fair, what was the general opinion about Chicago?
   a. It was an amazing, exciting city.
   b. It was not as impressive as Paris.
   c. It was a smelly, disgusting swamp.
   d. It had a large, beautiful lake.

Evidence: The Fair's organizers wanted to show that the United States, specifically Chicago, was just as capable of grand artistic and technological wonders as France. (If the organizers wanted to prove this, it must mean it was not accepted as fact.)

2. How were passengers able to stay upright as the wheel rotated?
   a. Each car was attached to its own axle.
   b. The wheel was powered by steam.
   c. The wheel had a large diameter.
   d. The main axle was made of forged steel.

Evidence: _____

3. Why was Ferris's proposal considered outrageous?
   a. It was larger than the other proposals.
   b. It was more expensive than the other proposals.
   c. It seemed physically impossible to build.
   d. It was far more beautiful than the Eiffel Tower.

Evidence: _____

4. Why did Burnham eventually approve Ferris's proposal?
   a. He knew the wheel would be popular and attract tourists to the fair.
   b. The approval of other engineers helped convince him it would be safe.
   c. He didn't get any other proposals that interested him as much.
   d. He thought it would be more impressive than the Eiffel Tower.

Evidence: _____

5. Why was the Ferris wheel the star of the fair even before opening day?
   a. Because it was more beautiful than the Eiffel Tower in France
   b. Because it was a lot of fun to ride on a wheel above the city
   c. Because the mechanics of its design were interesting to engineers
   d. Because people could see it being built and got excited about it

Evidence: _____

Vocabulary Activities STEP I: Word Level

A. Read this passage about an activity that requires precision engineering. Fill in the blanks with the target vocabulary in the box.

credit	obtain	regulations	revised
drafted	prior to	revise	violate
input	regulate		

Bungee jumping is a popular activity for the thrill-seeking type. It involves jumping from great heights with an elastic rope attached to your ankle. Just (1) _____ the moment when you would hit the ground, the elastic rope snaps you back up into the air.

Originally, a form of bungee jumping was practiced by people living on a few islands in the South Pacific. Modern bungee jumpers have (2) _____ the materials and methods of the sport and transformed it into a huge commercial enterprise around the world.

Bungee jumping businesses employ people with a strong knowledge of engineering to (3) _____ data on many different aspects of the activity: the distance of the drop, the elasticity of the ropes, the effects of factors such as weather conditions and a person's weight and height. These engineers seek the (4) _____ of other experts, and even the bungee jumpers themselves, to help them create safe conditions.

Because of the danger involved in the sport and the complicated nature of the calculations involved, some places have (5) _____ legislation to (6) _____ the bungee jumping industry. These lawmakers deserve (7) _____ for improving safety standards. The bungee jumping industry welcomes these (8) _____ , since they clarify the steps they need to take to improve safety. Companies that (9) _____ the regulations can be sued by injured customers. Most places continue to (10) _____ their laws as they learn more about the physics of bungee jumping.

B. **What is your opinion? Circle the answer that best reflects what you think. Discuss your answers with a partner.**

1. Which of these is the *briefest* activity for people your age?
   a. Eating lunch on a school or work day
   b. Getting ready for the day in the morning
   c. Having a phone conversation with their mother or father
2. Which of these is the worst thing to *violate*?
   a. A company or school policy
   b. An agreement with a friend
   c. The trust of a family member
3. Which of these is the most difficult thing to *draft*?
   a. Plans to build a house
   b. A chapter for a book
   c. A piece of legislation
4. Which of these things is the most difficult to *obtain*?
   a. A high-paying job
   b. An advanced degree
   c. Power over others
5. Which of these actions can most improve a *paragraph*?
   a. Revising it
   b. Rewriting it completely
   c. Leaving it alone

C. **Put a check (✓) next to the activities that you think should be regulated by the government. Then, in a small group, choose the five that are most important to regulate and rank them, with 1 as the most important and 5 as the least important. Share your answers with the class.**

___ selling cigarettes
___ owning pets
___ wearing seatbelts in a car
___ having children
___ wearing a bicycle helmet
___ owning a gun
___ place of residence
___ daily water use
___ eating unhealthy foods
___ violent movies

D. **Choose the best collocation (words that go together) in parentheses to complete the sentence. Write the complete sentences in your notebook. Compare sentences with a partner.**

1. Information (*obtained by / obtained with / obtained against / obtained for*) child safety researchers indicates that many playground designs are unsafe for children.
2. Playgrounds are (*credited for / credited in / credited with / credited to*) causing over 150,000 accidents each year, most of which are due to design flaws like inappropriately high structures or unnecessarily hard surfaces.
3. These poorly designed playgrounds exist partly because few places have drafted (*regulations on / regulations against / regulations with / regulations from*) playground safety.
4. The government tries to ensure that school playgrounds do not violate any of the engineering standards set for child safety, but it does not give (*input in / input from / input on / input for*) public parks.
5. As parents become more concerned about outdoor play equipment that they purchase for their children, some companies have begun to cover their packaging with (*paragraphs at / paragraphs from / paragraphs of / paragraphs to*) explanation about the safety standards they use to design their products, or, at the very least, a brief list of its safety features.

E. **Read these sentences about another kind of entertainment that uses physics for fun. Then rephrase the sentences in your notebook using the target vocabulary in parentheses. There may be several possible answers. Compare sentences with a partner.**

1. A Canopy Tour is an activity in which people travel in short sliding jumps on a system of cables and platforms through the tops of the trees in a rainforest. (*brief*)

   A Canopy Tour is an activity in which people travel in brief sliding jumps on a system of cables and platforms through the tops of the trees in a rainforest.

2. It is not descended from a local ancient cultural ritual, but originated in Central America in the 1970s, when it was developed by scientists to research local plants and wildlife that were previously inaccessible. (*tradition, prior*)
3. As Canopy Tours have developed into tourist attractions in a variety of tropical locales, many businesses have received permission to operate them. (*obtained*)

A Canopy Tour

4. As the tours increase in popularity, different countries have developed a variety of rules for safety—some stricter than others—and the Association for Challenge Course Technology helps inform consumers about which tour programs break these rules. (*regulations, violate*)
5. In addition, groups of tour providers have written voluntary guidelines with sections detailing regulations for guide training, equipment standards, and safety inspections. (*drafted, paragraphs*)

To *distort* means "to change the shape or sound of something." *Distortion* is the result.

The old mirror is not flat, so it ***distorts*** *my reflection and makes me look very tall.*

It is often used in a more figurative way, to mean "misrepresent."

Many people felt the senator ***distorted*** *the facts in order to sway public opinion in his favor.*

CORPUS

F. Reword these sentences in your notebook using a form of *distort*. Compare your sentences with a partner.

1. When cartographers make maps, they have to change the shape of countries and oceans in order to make a three-dimensional object fit in two dimensions.

   When cartographers make maps, they have to distort the shape of countries and oceans in order to represent a three-dimensional planet in two dimensions.

2. With maps that use the Mercator Projection, the north-south and east-west angles have the same amount of stretching, which makes land masses far from the equator appear unusually large.
3. Although use of the Mercator Projection has been criticized as causing the production of inaccurate shapes, it has been used for many years and is still very popular.
4. Recently, developers in Dubai used the Mercator Projection to change the shape of the coastline, creating "The World," a group of man-made islands that look like land masses on a map of the world.
5. Islands representing different countries can be bought by private owners, who can then further change their shapes, creating tourist attractions and amusements.

Before You Read

Read these questions. Discuss your answers in a small group.

1. Have you ever been on a roller coaster? If so, what was that experience like? If not, why not? Would you like to ride on one?
2. Do you think most amusement park rides are safe? Why or why not?
3. What effect do roller coasters and other rides have on the body? How are these effects different from the normal stresses people experience every day?

Read

This magazine article discusses the physics of safety related to the engineering of thrill rides.

SUMMER FUN UNDER SCRUTINY

When summer hits, it's amusement park season. Crowds rush the open doors of theme parks across the world. In Istanbul, it's Luna Park. Paris, Tokyo, and Los Angeles have Disneyland. Some people wait in line for hours for their favorite rides. Roller coasters provide much of the draw for young and old alike. There's the thrill of the height, the rush of sound, the feeling of being weightless, and then the falling down, down, down! In fact, the names of the rides alone hint at the thrill that is to come: Australia has the Tower of Terror and Japan the Steel Dragon.

But is this summertime **tradition** safe? A quick glance at the national newspaper headlines from July 2011 makes the thrills seem hardly worth the risk. "Freak roller coaster accidents cause concern over their safety," reads one article. At a theme park in New York in the United States, a twenty-nine-year-old father was thrown from the roller coaster Ride of Steel as it made its rapid descent. He was wearing a safety belt at the time. A couple of days later in the state of Texas, riders were suspended 14 stories up in the air for over 30 minutes before being able to climb down an emergency stairway to safety.

These accidents lead to questions about how roller coasters are **regulated.** What went wrong on the Ride of Steel to result in a man's death? Many times in accidents such as these, the cause is not clear. In this particular case, an investigation by the Department of Labor was conducted to **obtain** more information. The department found that it was not that the roller coaster was unsafe, but that the ride operators **violated** the rules. On this ride, safety devices restrain the legs, shins, and lap to secure each person in the car. The rules required riders to have both legs so they can be properly secured on the ride. The man who was thrown, however, didn't have either of his legs, but he was still permitted to board the ride.

As a result of this death, the park implemented new practices. Now all employees who operate the ride must be

retrained in safety procedures, new signs must be posted that specify the safety regulations, and park management must now review the safety procedures **prior** to a ride operator's shift.

However, it's not just the adventure seekers that are in danger. Rides aren't fully **automated**; they need operators. Unfortunately, operators have also been the victims of accidents. A twenty-four-year-old ride operator in Sautron, France, died when he left the control booth and his legs were crushed under the ride. In order for rides to operate safely, both riders and operators have to adhere to rules and restrictions. In the Ride of Steel accident, the theme park was initially accused of employing ride operators that were under the legal **adult** age of eighteen. New York state law requires ride operators to be at least eighteen years old. In later reports, the park was able to clarify that the operators of the ride were over eighteen.

Even if passengers and ride operators follow guidelines, are roller coasters safe? Each year, as amusement parks compete to draw in crowds, new, faster, and taller roller coasters are built. In 2011, Japan opened what is claimed to be the world's steepest roller coaster. Its name *Takibisha* means "high-flying car." And in fact, riders may feel like they are flying or actually falling as they experience its steepest drop from the dizzying height of 141 feet at an angle of 121 degrees. In Abu Dhabi, the roller coaster Formula Rossa holds the record for the fastest speed at 149 miles per hour. If this sounds fast, that's because it is. The average passenger airplane, such as a Boeing 757, reaches a speed of about 160 to 180 miles per hour at takeoff.

In fact, the same software and technology being used to develop aircraft like Boeing's is what is making such dramatic heights, speeds, curves, and thrills possible on new roller coasters. Jim Seay, president of the roller coaster design firm Premier Rides, explains in an article for *Popular Mechanics* that roller coasters are able to reach extreme speeds and heights because of "new engineering tools, quicker computers and exotic materials." He adds that "high-tech materials like carbon-fiber composites opened the door to more sophisticated designs because they reduce

People of all ages love the thrill of roller coasters.

weight and the resulting stresses on large support structures." This new technology affects everything from the shape and design of the roller coaster to the motors that power it. For example, computer-aided design allows engineering feats resulting in rides like Fahrenheit, in Pennsylvania, that propels riders down at a 97-degree angle. That is seven degrees past a vertical drop. New linear induction motors, which are designed to accelerate an object to a very high speed with magnetic waves, are used in a ride at Six Flags in the United States. Riders reach speeds of 70 miles per hour in only 4 seconds.

It's no wonder that critics and safety advocates worry about the trauma caused by traveling at such speeds. Douglas Smith, a University of Pennsylvania neurologist, conducted tests in 2003 to analyze how a person's head rotates while on a ride. It's the rotation of the head, along with the excessive speeding up and slowing down, that is the main cause of brain injury. He found that people's head rotation and acceleration and deceleration while on rides were not at levels that would cause brain injury. Since then, he's repeated the study, and initial data support his first findings.

Yet doctors will continue to issue warnings, as will riders who have experienced injury firsthand. A recent article in *Popular Mechanics* links roller coaster riding with

hearing loss. One doctor, whose patient turned his head during a ride and suffered an eardrum-blasting pressure, explained: "The faster the ride moves and the larger the change in altitude, the higher the force that is applied to the ear." This is why he now recommends that people look straight ahead while riding roller coasters. However, Bryan Pfister, a biomedical engineer at New Jersey's Science and Technology University, conducted a study that found the effect on the head during a roller coaster ride to be similar to the wallops one receives while pillow-fighting or playing sports.

With his findings, he questions whether the accidents from roller coasters are a real threat or a freak occurrence.

It's no question that accidents from roller coasters can be serious and even fatal, and that the public and the amusement parks themselves can benefit from a serious look at ride regulations and requirements. The future is only going to bring more innovative design and more pulse-pumping rides. And for every new roller coaster, there's likely to be a line of eager riders wrapping around the corner.

Reading Comprehension

Mark each sentence as *T* (true) or *F* (false) according to the information in Reading 2.

___ 1. The world's fastest roller coaster moves at higher speeds than a Boeing jet.

___ 2. New York State Law requires that ride operators be at least sixteen years of age.

___ 3. According to Douglas Smith's 2003 findings, ride acceleration and deceleration were not at levels that would cause brain injury.

___ 4. Abu Dhabi's Formula Rossa is the steepest roller coaster in the world.

___ 5. An investigation into the accident that occurred on the Ride of Steel revealed that ride operators had not followed safety regulations.

READING SKILL Making Inferences

APPLY

Answer these questions in your notebook. You will need to make inferences. Support your inferences with evidence from Reading 2. Discuss your answers and inferences with a partner.

1. How does Pfister's study support the argument that roller coasters do not cause brain injury?
2. What can be inferred from the following sentence?

   Each year, as amusement parks compete to draw in crowds, new, faster, and taller roller coasters are built.

3. Are the New York regulations for ride operators necessary? Why or why not?

Vocabulary Activities STEP I: Word Level

A. **Read these excerpts from an article about New Jersey state's (in the United States) safety regulations on amusement parks. For each excerpt, cross out the one word or phrase in parentheses with a different meaning from the other three choices. Use a dictionary to help you understand new words. Compare your answers with a partner.**

1. According to New Jersey's plan, forces on a new ride must not exceed limits outlined by the state. New rides that exceed those limits are not (*clearly / immediately / instantly / automatically*) rejected, but will be subject to a more extensive review.
2. The plan is based partly on research done in Russia. Legislators there have (*written / accepted / drafted / composed*) a set of (*regulations / rules / structures / policies*) based on military aviation tests on physically healthy (*adult / grown / mature / serious*) individuals.
3. New Jersey regulators also looked at research done in Europe on neck injuries, although this research studied only the (*usual / traditional / dangerous / conventional*) gravity-driven coasters, not the newer, potentially more dangerous coasters.
4. New Jersey regulators relied on research from other countries because they were unable to (*review / acquire / obtain / get*) injury records for the 150 U.S. roller coasters that they studied.

B. **Which of these tasks have been automated? Discuss your answers with a partner.**

___ washing dishes
___ brushing your teeth
___ watering the garden
___ answering the phone
___ making coffee
___ washing clothes
___ cleaning the floor
___ mending torn clothes
___ feeding a child
___ brushing your hair

C. Most societies regulate certain activities that can be done only by adults. Some also have activities that can only be done by children. Next to each item below, write—

A for activities regulated for adults
C for activities regulated for children
B if an activity is regulated for both adults and children
N if no regulation exists.

___ earn money for working
___ stay at home alone
___ ride the bus alone
___ drive a car
___ get married
___ buy cigarettes
___ get a secondary school degree
___ open a bank account
___ have an email address
___ watch a violent movie
___ play on a sports team

Compare answers with a partner. Discuss how each item is regulated, who is responsible for the regulation, and how regulation changes in different contexts.

D. Complete the passage using the target vocabulary in the box.

brief	input	prior to	violated
credit	paragraph	revise	

Many amusement parks ask for (1) _____ from lawyers when creating their safety policies. They want to protect guests from danger, but they also want to prevent injured customers from taking them to court. For example, while waiting in line, park visitors may see a sign posted near the entrance with a lengthy (2) _____ explaining who should or should not go on this ride. Guests may also have to watch a (3) _____ safety demonstration (4) _____ getting on the ride. Then, if riders are injured, the park cannot be held responsible for the injury. The park can show that the visitors knew the safety policies but (5) _____ them anyway.

A lawsuit from an injured rider can damage the reputation of an amusement park for years. Legal advisers carefully (6) _____ the warnings on a regular basis to make sure they are up to date and cover every possible problem. Park owners (7) _____ their strict safety policies and the help of their legal advisers with protecting their good name and their profits.

Vocabulary Activities STEP II: Sentence Level

E. Most countries have regulations that describe how people should behave when they drive cars. In the boxes on the left, write examples of driving regulations that you think are important. On the right, write examples of punishments that you think would be appropriate for people who violate those regulations.

Driving Regulation	Penalty for Violation
No talking on the cell phone while driving	*large fine*

F. Imagine that you have the chance to interview the inventor of one of the rides described in this unit. What would you ask? Write interview questions using as many of the target words in this unit as you can. You might have to do some research online. Consider these issues as you prepare your interview questions:

- how the ride works
- what it looks like
- why people like it
- the history of how the inventor developed this ride
- what sort of safety guidelines it requires

Be prepared to use your questions to role play an interview with a partner in class.