Newton's Laws, a Moving Experience

Isaac Newton was the first person to scientifically explain why objects move the way they do. He developed three laws of motion. His laws help explain the relationships among force, matter, and motion.

Newton's First Law

If you start a ball rolling, it will keep moving in that direction with the speed you gave it unless something stops it, slows it, or changes its path. Newton's first law says that until an object is acted upon by an external force, it remains in its current state. If the object is at rest, it will remain at rest. If it is in motion, it will remain in motion.

Newton's first law is called the *law of inertia.* Inertia is a property of matter. Inertia causes matter to resist changes in its motion. In his first law, Newton stated a new idea—that moving is as common a condition as resting.

The mass, or amount of matter, of an object is a measure of its inertia. All objects at rest resist motion. Objects with more mass resist motion better than those with less mass. For example, blow very lightly on a feather and it will move. Blow on a 50-pound steel ball as hard as you can, and it will not budge. The mass of the steel object resists being moved by the push of your breath. The steel ball has more inertia than the feather.

If you push hard enough on the 50-pound ball, it will move. Once moving, it will tend to keep moving, too. That is also because of its inertia. You will have to apply just as much force to stop the 50-pound ball as you did to get it moving in the first place.

Newton's Second Law

What happens to a ball when it is acted on by a force?

It will accelerate—increase in speed—in the same direction as the force. A steady force causes a steady increase in speed. Any sort of push or pull is a force. The greater the force, the faster the object accelerates. Also, the longer the force lasts, the faster the object will be moving when the force stops. That means that both small and large forces can accelerate an object to the same final speed. It just takes the small force a longer period of time.

Newton's second law, about force and motion, is usually written in this simple formula:

$$F = ma$$

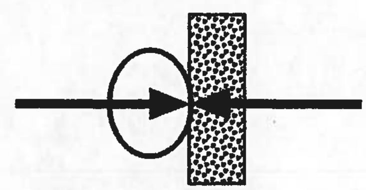
It can be rewritten as:

$$a = F/m$$

In words, *force* equals *mass* times *acceleration.* Or, acceleration varies inversely with mass and directly with force. For example, pull back the plunger of a pinball machine as far as it will go. Newton's second law says a lighter ball will be traveling faster than a heavier ball launched with the same force. Can you think of a way to test this?

Newton's Third Law

If the pinball hits a wall, it bounces back. Why? Because when the ball hits the wall, it exerts a force on the wall. This causes the wall to exert an opposing force on the ball. The opposing force is always of equal strength but opposite in direction. The ball acts on the wall, and the wall acts on the ball. For every action, there is an equal and opposite reaction. This is Newton's third law of motion.



Newton's third law states that forces always occur in pairs acting in opposite directions and on different objects.

Law number three is all around us. Feel the recoil of a garden hose when you turn it on. Step from a boat and feel the boat move away as you step forward. Strike a nail with a hammer and see the hammer bounce as the nail hits back.

The next time you watch the space shuttle head skyward, remember you are watching Newton's third law in action. As the engines spew tons of matter from their nozzles, the matter pushes back. It is the reaction that pushes on the shuttle and forces it to rise.

DISCOVERY FILE

Science Friction

Friction is nature's way of saying no. Newton's first law of motion states that an object in motion will remain in motion unless it is acted on by a force. Try this experiment. Start a ball rolling across a bare floor. Does it move forever, as Newton's first law suggests? If not, what is the force that slows the ball to a stop?

Friction is the force that resists motion. Friction is caused when a moving object makes physical contact with a surface—the ball contacts the floor.

Contact between a moving object and the medium through which it is moving also causes friction, such as a car moving through air and a boat moving through water. Friction is also caused by moving parts rubbing against other parts, such as an axle spinning inside a bearing. Friction pushes or pulls, slowing a moving object until it stops.

A roller coaster slows due to friction. When roller coaster wheels rumble over the track, friction between the wheels and the track opposes the coaster's motion.

Friction is also a destructive force. It causes wear and creates unwanted heat between the surfaces in contact. Coaster car builders sometimes use special material on wheels and rails to reduce friction.

Air also resists the roller coaster's movement. Friction caused by movement through the air is called *drag.*

When engineers build roller coaster rides, they take friction into account. Without friction, a roller coaster car released from the top of one hill could climb to the top of the next hill of the same height.

But friction causes energy loss. Friction transforms the mechanical energy of the turning wheels into heat energy. The heat energy is lost to the air.

At the top of the first hill, the coaster car has lots of potential energy. As gravity pulls the car downward, the potential energy becomes mechanical energy—a form of kinetic energy. Because the cars lose some of that mechanical energy to heat through friction, each hill on a coaster ride must be somewhat lower than the first hill.

The longer the ride, the greater the energy loss and the lower the hills have to be. The total energy of a ride does not increase or decrease, but the energy changes from one form to another form.

All this is not science fiction, it is science fact.

DISCOVERY FILE

Mass and Weight

What is the difference between mass and weight?

Mass is the amount of matter an object contains. You have mass. Everything in the universe has mass. All objects have this property.

The mass of an object never changes by itself. The object can be on Earth, near Earth, or by a distant planet, and its mass remains constant.

The mass of an object is a measure of the object's inertia—resistance to change in motion. Inertia governs how an object responds when a force is applied to it.

Weight is the force gravity exerts on the mass of an object. An object has weight only in relation to gravity.

Different sizes of objects have different gravity. For example, the gravity on the Moon is one-sixth the gravity on Earth. If you weigh 100 pounds on Earth, you would weigh about 17 pounds on the Moon.

Weight even changes on Earth itself. A brick placed in a deep valley below the level of the sea will weigh very slightly, but measurably, more than the same brick placed on top of a mountain. In Death Valley, California, a brick is closer to Earth's center than it is on the top of Mount Whitney. The closer you are to the center, the greater the pull of gravity.

SCIENCE ACTIVITY

Brake It, But Don't Break It!

Purpose

To use Newton's laws of motion to design a ramp that can transport fragile materials safely.

Background

You and your partners are industrial engineers working at a glassware company. At the warehouse, cartons of fragile glassware are stored in a loft above the ground floor. The president of the company has given you the job of designing a ramp for carts to carry boxes of glassware down to the main floor. The ramp must fit in a relatively small area and get the glass down quickly but without breakage.

The president decided it will take too long to wrap each glass with protective padding or to fasten the boxes down. Speed alone must provide the margin of safety.

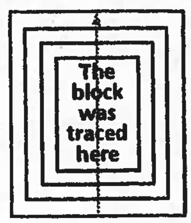
Materials

For each group:

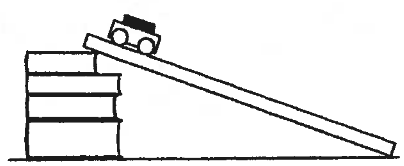
- Cart on wheels
- 2 or more wooden blocks smaller than the cart
- Long, flat board
- Meterstick
- 6 or more sheets of grid paper
- Assorted materials to slow the cart at the end of the ramp
- Thick books
- Masking tape

Procedure

1. Cut a piece of paper the size of the top of the cart. Trace the shape of one block on the center of the paper. The block must be smaller than the cart and free to move in any direction on it. Measure outward from the tracing and mark the paper every 0.5 centimeters in all directions. Draw an arrow down the middle of the figure. Tape the paper to the cart with the arrow pointing forward. During trials, the block should not move.



2. Place the block on the paper exactly where you traced it. Do not tape it down or do anything else to keep it from moving.
3. Create a table to record such data as track height, start and stop distance, number of blocks, and block movement. Each time you have a trial as explained in steps 5, 6, 8, and 10, record data in the table.
4. Prop up one end of the board on a stack of books or other support. You may notice there is a big bump at the bottom of the ramp. Design a way to lessen or get rid of this bump.



5. Start the cart at various positions on the ramp. Record each position as the distance from the starting position to the base of the ramp.
6. Release the cart. Measure and record the distance from where it starts to where it stops. Decide on a number of trials you think will show the relationship between starting positions and distances rolled. Keep track of any movement of the wood block.
7. On grid paper, plot the relationship between starting position and total distance. Do not connect the points.
8. Now explore the effect of varying the steepness of the ramp. This time, always start the cart from the same position on the ramp. Only vary the steepness. Record steepness as the height of the top end of the ramp. Record the total roll distance for each trial.
9. Use your data table to plot the points on grid paper. Do not connect these points.
10. Vary loads on the cart by adding blocks. These represent boxes of glassware, so you must not let the blocks move or fall off as they travel. Record your data on another sheet of grid paper.
11. Stop here and answer questions 1 through 4 in the Conclusion.

Now that you have finished the preliminary tests, it is time to prepare your design for the warehouse ramp. Your teacher will ask you to set up the ramp at a certain steepness. This time, you may use materials to stop the cart after it rolls down the ramp. The block should not move much after hitting the barrier. The group that does the following will win the contract with the glassware company:

- has the cart starting at the the highest position on the ramp
- stops the cart in the shortest distance
- moves the load the least

Keep the block loose on the cart. The cart must run out (down) on a flat (not uphill) surface. After the competition is over, answer question 5 and the Extension.

Conclusion

1. Make a final copy of the graphs showing run distances related to ramp lengths and to ramp steepness (height). Choose a creative way to show the results of the load test. What effect does a longer ramp length have on run distance? What effect does a steeper ramp have on run distance?
2. What would happen to the blocks if the cart ran into a solid barrier? How does this observation show Newton's first law (the law of inertia)? (See the Discovery File "Newton's Laws, a Moving Experience" on page 23.)
3. What kind of energy does the cart have before it starts to roll down the ramp? (See the Discovery File "Indestructible Energy" on page 17.) Describe the energy transformations as the cart rolls down the ramp and as the cart rolls along the flat surface. What is the cart's energy at the end of the run?
4. Describe the procedure you used to prepare for the competition. If your blocks moved or fell off the cart, what was the cause?
5. How can the results of this experiment be applied to the design of amusement park rides?

Extension

In mountainous regions, road builders construct runaway truck ramps near the bottoms of long hills. These ramps allow a truck with failed brakes to leave the main road and coast uphill to a stop on a sand or gravel-filled path. Explain why the sand or gravel helps stop the truck.

STUDENT VOICES

I like the White Water Rapids because you get wet and there are lots of bumps and stuff. It's cool.

Thrill rides should have good features, like going very fast with lots of turns . . . things that will make you almost throw up.

CARLOS BACELIS
CULPEPER, VA

SCIENCE ACTIVITY

Roller Derby

Purpose

To roll a ball down a track so it comes to a stop at a predetermined point, and to analyze energy transformations experienced on a slide.

Background

You are designing a slide attraction for a traveling carnival. For a slide to be safe, the rider must slow to a stop at the end of the ride.

You cannot take any chances, so you build a scale model of the slide. Carnival officials want to see your design work successfully before they give you their approval to build the full-scale attraction. They are also interested in the energy transformations that occur. The longer the slide, the more the carnival officials will like it!

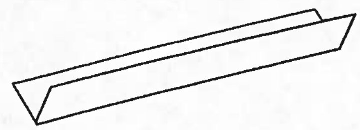
Materials

For each group:

- Meterstick
- Strips of poster board, flexible white tag board, or other material to make a track
- Tape
- Support materials (books, blocks, pieces of wood)
- A few different balls (such as a marble, table-tennis ball, and golf ball)
- Small cup
- Blank paper

Procedure

1. Use poster board or other materials to build a troughlike track. Connect several sections together with tape. Be sure the tape does not interfere with a rolling ball.



2. Set up the track so the starting point is at least 50 centimeters above the floor. Mark off in centimeters the section of track where you will start the ball rolling. Lay track elements end-to-end and carefully tape the sections together.
3. Position the track so the last segment of track runs uphill and the finish is a few centimeters above the floor. Place a cup under the end of the track.
4. Between the start and finish, the track can carry the ball downhill, uphill, or along a level path. The track can even curve, but somewhere along the way, it must touch the floor.
5. NOTE: Since this is a traveling carnival ride, the slide must come apart in several sections for transportation and storage. The longer your track, the more impressed the carnival officials will be.
6. Hold the ball somewhere on the upper part of the incline, and note the starting point. Let the ball roll down the track toward the finish line. If the ball is going too fast, it will shoot off the end of the track and miss the cup. If it is going too slowly, the ball will not make it to the end of the track.
7. Each time you roll the ball, record the starting position on the incline and note where the ball ends up. Keep adjusting until the ball falls into the cup at least twice in a row. Record the exact location where successful rolls began. Measure the height of this point above the floor. Also measure the height of the end of the track above the cup.
8. Try balls of different weights or sizes. Keep an organized data table.
9. Now it is time to demonstrate your attraction to the carnival officials. During your demonstration, you cannot touch or move either the ball or the slide. If it works, you are on your way! If it does not work, go back to the drawing board. If you have difficulty meeting this standard, others in the class will give suggestions as to how to fine-tune your model. Then you can make modifications and try again.

Conclusion

Since the carnival officials are looking at designs from several manufacturers, they want a written record of your design.

Include in the report a sketch of a side view of your slide. Mark the approximate starting location of the ball. Label where the ball's velocity is increasing, where it is decreasing, and where it stays about the same.

Whenever the velocity of an object changes, a force must be

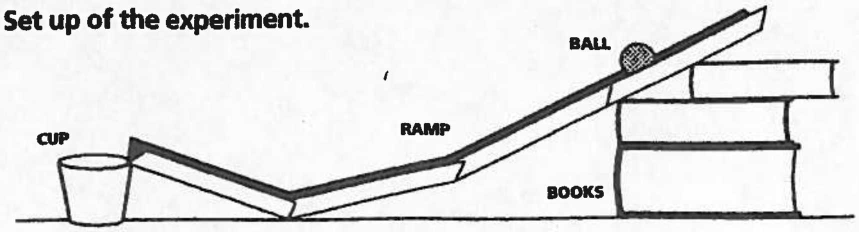
acting on the object. On the sketch, draw arrows to show the direction of the force or forces acting on the ball in different sections along the track. Use different colors of arrows for the different forces (such as black for gravity, red for friction, and green for centripetal).

These questions will help you analyze changes in the ball's energy during the ride.

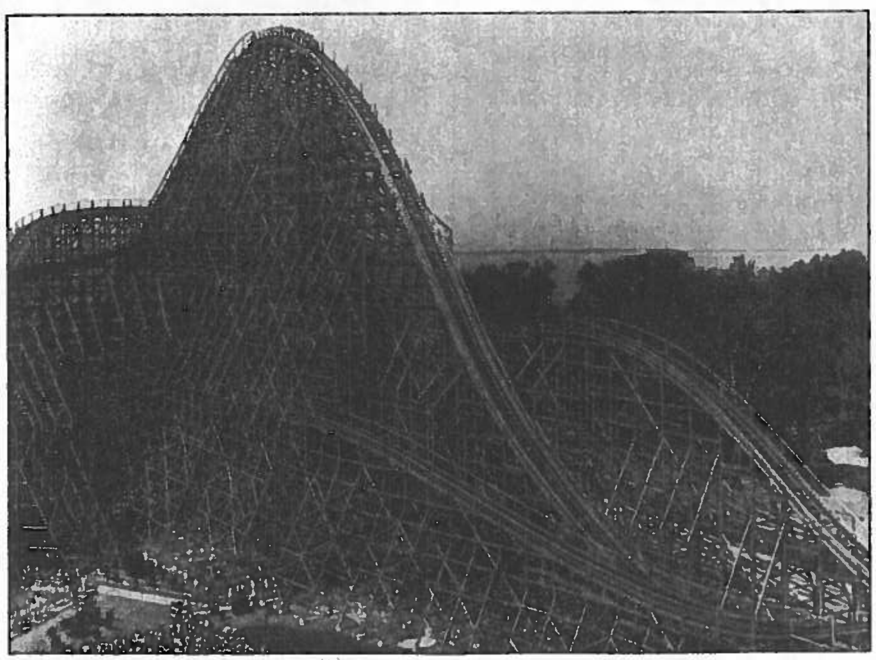
1. Before you let the ball go down the incline, what was the ball's kinetic energy? (Kinetic energy is the energy of motion.)
2. When the ball reached the finish line, it was hardly moving. At that point, what was the ball's kinetic energy (approximately)?
3. What is the height of the starting point (H_s) above the floor? What is the height of the finish line (H_f) above the floor?
4. What is the height of the starting point above the finish line? ($H_s - H_f$ = the vertical drop (D_v) of the slide.)
5. Where is the potential energy of the ball greater, the start or the finish?
6. If the kinetic energy of the ball is about the same at the start and finish, the loss of potential energy is due to friction. To find out the percentage of potential energy lost to friction, use this formula:
   Percent Lost to Friction =

   $$100 \times \frac{D_v}{H_s}$$

Set up of the experiment.



   or Percent lost to friction is equal to 100 times the vertical drop divided by the height of the starting point.
7. If you covered the track surface with strips of sandpaper, how do you think the sandpaper would affect the ball? Would you have to change the starting position of the ball?
8. If you kept your slide as it is, but used a heavier ball, how would that affect the starting position of the ball?
9. Would it be possible to design a slide with a hill in the middle higher than the starting position of the ball? Explain your answer.
10. Small models of systems in physical science do not perfectly represent the real thing. In what ways is your model not similar to an actual slide at a carnival? Generate a list with your group, then write the ideas on a sheet of paper. Compare your ideas with those of other groups and expand your list.



USA TODAY, 3 MARCH, 1995

Mean Streak roller coaster at Cedar Point in Sandusky, Ohio.

SCIENCE ACTIVITY

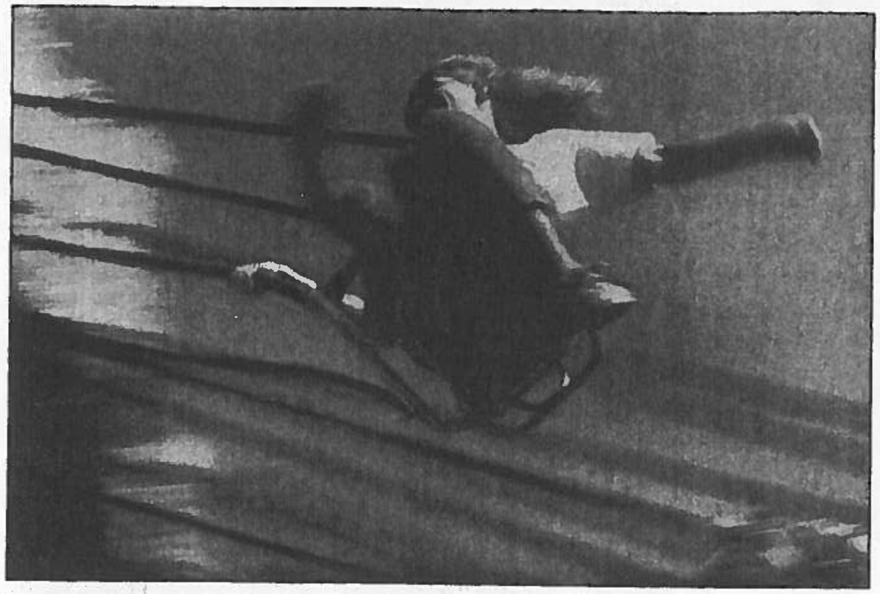
Give It a Whirl

Purpose

To investigate the forces exerted on a person riding on a revolving ride.

Background

You work for an amusement park ride design company. The company has asked you to design a new ride that has a seat attached to the end of a cable. The cable and seat should be able to extend outward as the ride revolves faster and faster. Build the ride so it demonstrates centripetal force and *G* force. A coworker has already designed a model that shows both. Your task is to incorporate the design into a new and different thrill ride.



Wave Swinger at Cedar Point in Sandusky, Ohio.

Materials

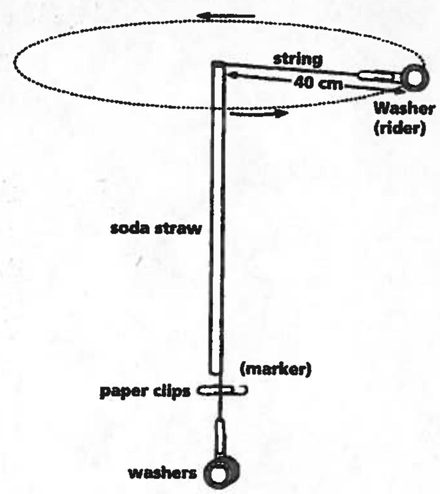
For each group:

- Goggles for each group member
- Plastic soda straw
- Meterstick
- 1 meter of string
- 3 large paper clips
- 10 small washers (all the same size)
- Clock or watch
- Several sheets of blank paper
- Markers or crayons

Procedure

1. Thread the string through a straw and tie a paper clip to each end of the string.
2. To simulate a rider, attach a washer to one of the clips. Attach two washers to the other clip. These two washers represent 2 *G*s of centripetal force on the rider.
3. Pull the rider end of the string so it extends 40 centimeters from the straw to the rider. Hold the rider at that distance while a partner attaches a paper clip to the string where it comes out of the other end of the straw. Do not tie it, because it has to move freely! This is the marker.
4. Hold the straw vertically with the two washers hanging down. Let go of the rider and record what happens.
5. Now start the rider whirling in a circle parallel to the floor. Increase the rate of spin until the marker clip is pulled up against the bottom end of the straw. Keep swinging the rider around so the marker clip spins freely just below the straw.

CAUTION: Keep clear of others while swinging the washer.



6. As one partner swings the rider around, another should count the number of circles made in 30 seconds. Make this count three times and take an average of the counts. Multiply the average by two to get the number of revolutions per minute (RPM) for the washer.

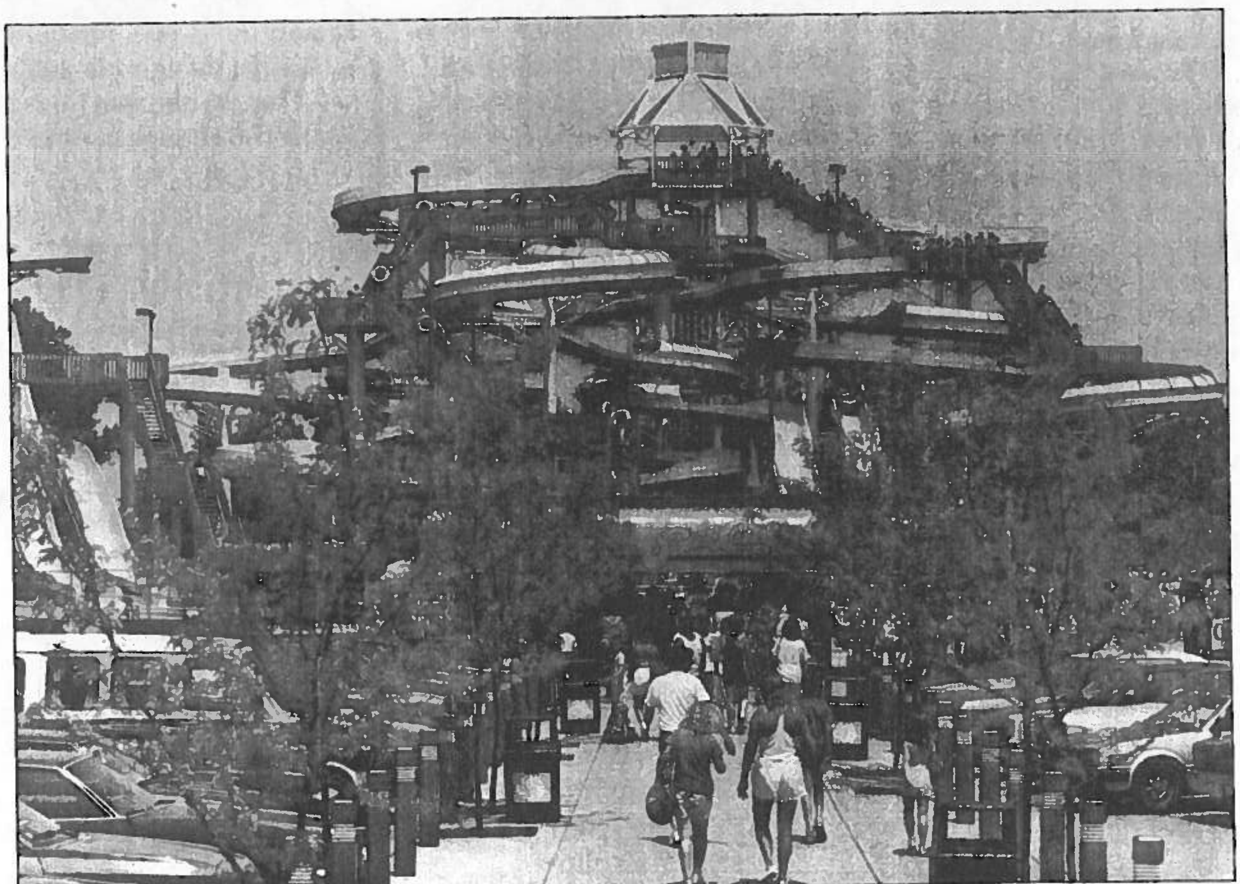
7. Sketch your contraption, estimating the angle formed between the straw and the rider.
8. Repeat the experiment several times with additional *G*s attached. Record your observations and draw diagrams of what you see.
9. Decide on a constant number of *G*s and run a set of trials using other distances between straw and rider. Try at least one distance greater than 40 centimeters and one less than 40 centimeters.
10. Display your results in a creative way.

Conclusion

The company you work for wants you to submit your whirling ride concept in the form of a diagram. What will it actually look like? They also want answers to several questions (see below).

Prepare a color drawing of a ride based on your experiments and prepare a memo to your company president with the answer to these questions:

1. What happened to the RPMs of the rider when you added additional *G*s?
2. What happened to the RPMs of the rider when you decreased the radius of the circular path?
3. As the number of *G*s increased, how did the angle between the straw and rider change?
4. The revolving rider is constantly changing its direction of motion. Newton's second law says a change in motion must be caused by a force. What produces the force that causes the circular motion of the rider? What happens to the motion of the rider as this force is increased?
5. According to Newton's third law, the rider must exert an equal and opposite force on the string. How did this experiment show this equal and opposite reaction?
6. Predict what would happen if the string attached to the rider suddenly broke. In what direction will the rider go?
7. What new things did you learn about the design of amusement park rides from this activity?



Soak City at Cedar Point in Sandusky, Ohio.

SCIENCE ACTIVITY

The Swing of Things

Purpose

To study forces that influence the motion of a pendulum, and to identify energy transformations in pendulums.

Background

You are an amusement park operator with a pendulum ride. All it does is swing people back and forth. The ride was very popular when it first opened. Long lines formed as people anxiously awaited their chance to swing. Now, the pendulum ride has lost its appeal. You are losing money staffing it, and you must do something to make it interesting again.

Some of the complaints from riders are, "It doesn't last long enough," and "It's not very exciting. I want a real thrill out of this ride." Before you meet with the design engineer, you want to learn more about pendulum motion so that you will not sound like a swinging idiot during the meeting.

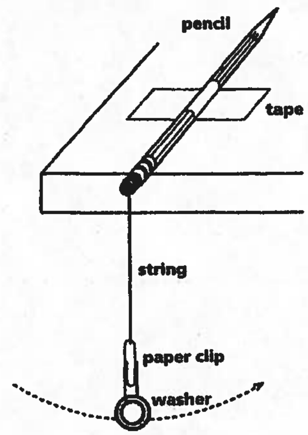
Materials

For each pair:

- About 150 cm of string
- Scissors
- Pencil
- Masking tape
- Large paper clip
- 5 or more washers
- Meterstick
- Clock or watch

Procedure

1. Tape a pencil to the edge of a desk or table so the eraser part extends beyond the edge. If other supports are available, use them too. The pencil acts as the pendulum's pivot point.



2. Measure about 50 centimeters of string and tie a paper clip to one end. Slip one washer on the paper clip. Attach the other end of the string to the pencil. Carefully measure and record the length of the string from the pencil to the center of the washer.
3. Pull the washer to the side about 20 centimeters and let it swing. Count the number of full swings (back and forth) in one minute. Repeat the procedure and find the average. Record this average number of swings in a data table. Also describe what happens to the size of each swing (its *amplitude*) as time passes. This first set of trials represents the unpopular ride you want to change.
4. What variables (such as string length) can you change to test different pendulum designs? Conduct a series of experiments, changing one variable at a time. Each time you run an experiment, record the number of swings in one minute. Record what happens to the amplitude after one minute. Present the data in an organized form.

Conclusion

Making the swing ride more interesting will cost money. But as they say, it takes money to make money. Prepare a memo to the owners of the amusement park. In the memo, state your recommendation for making the swing ride more interesting. Estimate the cost of the changes required (any reasonable estimate will be accepted). In addition, you must explain the science behind your recommendation.

Be sure to explain the science in simple terms. The owners of the amusement park are scientifically illiterate.

Here are some questions to consider as you write your memo.

1. What force keeps a pendulum going? What forces cause a pendulum to come to a stop?
2. At what point in a pendulum's swing does the washer have the most potential energy? At what point does it have the most kinetic energy?
3. What is happening to the total energy of the pendulum as time goes on?
4. Will lifting the ride higher at the start produce a longer ride or faster ride?

DISCOVERY FILE

It Sounds Like Work to Me

According to scientists, math homework is not work. Science homework is not work either. Then what is work?

To a scientist, *work* has a very precise meaning. Work is done when a force acts on a mass and causes it to move. The amount of work done is the product of the force exerted times the distance moved.

work = force x distance

Energy is related to work because it takes energy to do work. Units of energy are measures of the amount of work done. The joule is the unit of energy in the metric system. One joule is the amount of energy needed to produce 1 newton of force over a distance of 1 meter.

Energy may be electrical, mechanical, chemical, thermal, or nuclear. It can be used now or stored for later use. Stored energy (potential energy) has the capacity to do its work in the future. Kinetic energy is doing its work now.

A tightly stretched rubber band has potential mechanical energy. Can you think of other examples of stored energy?

SCIENCE ACTIVITY

So Nice of You to Drop In

Purpose

To apply Newton's second law to the motion of falling objects, and to design and demonstrate a parachute-drop device.

Background

A famous amusement park company has hired you and your partner(s) as consultants. They need your help designing a parachute ride. Their attorneys are worried. A parachute that drops too fast might injure riders. The parachute must also land the riders in a small area directly under the release point. Otherwise, people might crash onto the shaved ice stand.

Before you draft your reply, you have a few days to use the laboratory to sharpen your understanding of falling objects and parachute design.

Materials

For each group:

- Paper clip
- 5 washers
- Several meters of string
- Scissors
- Stopwatch
- Hoist mechanism or cardboard tube with extra string (optional)
- Several sheets of blank paper
- Tape

Procedure

1. Slide five washers onto a paper clip, then devise a way to drop this mass from a high place in the classroom. The drop height should be a minimum of 3 meters. Measure the drop height to the nearest hundredth of a meter.
2. Use a stopwatch to measure the free-fall drop time for the mass to the nearest tenth of a second. Repeat for a total of five trials. Create a table to record the data. Record times in nearest tenths of seconds. Calculate and record the average free-fall time.
3. Use the chart to find a calculated drop height based on your average free-fall time. If time permits, collect data for other heights.

Drop Heights

Free-Fall Time (s)	Drop Ht (m)	Free-Fall Time (s)	Drop Ht (m)	Free-Fall Time (s)	Drop Ht (m)	Free-Fall Time (s)	Drop Ht (m)
0.05	0.01	1.05	5.40	2.05	20.59	3.05	45.58
0.10	0.05	1.10	5.93	2.10	21.61	3.10	47.09
0.15	0.11	1.15	6.48	2.15	22.65	3.15	48.62
0.20	0.20	1.20	7.06	2.20	23.72	3.20	50.18
0.25	0.31	1.25	7.66	2.25	24.81	3.25	51.76
0.30	0.44	1.30	8.28	2.30	25.92	3.30	53.36
0.35	0.60	1.35	8.93	2.35	27.06	3.35	54.99
0.40	0.78	1.40	9.60	2.40	28.22	3.40	56.64
0.45	0.99	1.45	10.30	2.45	29.41	3.45	58.32
0.50	1.23	1.50	11.02	2.50	30.62	3.50	60.02
0.55	1.48	1.55	11.77	2.55	31.86	3.55	61.75
0.60	1.76	1.60	12.54	2.60	33.12	3.60	63.50
0.65	2.07	1.65	13.34	2.65	34.41	3.65	65.28
0.70	2.40	1.70	14.16	2.70	35.72	3.70	67.08
0.75	2.76	1.75	15.01	2.75	37.06	3.75	68.91
0.80	3.14	1.80	15.88	2.80	38.42	3.80	70.76
0.85	3.54	1.85	16.77	2.85	39.80	3.85	72.63
0.90	3.97	1.90	17.69	2.90	41.21	3.90	74.53
0.95	4.42	1.95	18.63	2.95	42.64	3.95	76.45
1.00	4.90	2.00	19.60	3.00	44.10	4.00	78.40

4. Make a parachute out of paper and fasten it to the five-washer mass using short lengths of string. The parachute can be any shape.
5. Tape a small paper loop to the top of the chute so you can hold the mass at the drop height. Start the mass under the parachute at the same drop height as you did for the free-fall trials.
6. Let go of the parachute. Find and record the parachute drop time. Repeat for five trials, and calculate the average parachute drop time. Organize your data into a table.
7. Now perfect your parachute. You may redesign it in any way, but your goal is to have the drop time as long as possible and the landing as accurate as possible (directly under the drop point). Demonstrate your design for the class.
8. When all groups have demonstrated their parachute drops, brainstorm as a class why some designs worked better than others. Take notes during the discussion of points a–f below. The answers will help you with your response to the amusement park company.
   a. Compare the height you got from the chart provided with the measured drop height of the object. If the two heights are not equal, suggest reasons why they are different.
   b. What do you think would happen to the free-fall time if you dropped a more massive object from the same height? How about something with less mass? Speculate, then experiment to test your ideas.
   c. Release a mass to fall freely to the floor. Compare the mass's speed just after release with its speed near the floor. Make the same comparison for a mass with a parachute attached to it.
   d. According to Newton's second law, any acceleration is caused by a force or a group of forces acting together. Compare the acceleration of the free-fall mass to the mass on the parachute.
   e. Discuss what other force or forces might be canceling

the effect of gravity when you use a parachute to drop a mass.

f. Your challenge was to design a parachute that causes the mass to drop in the longest time while landing directly below the drop point. From the brainstorming you did with your colleagues, what things made some designs work better than others? Which was more difficult, slowing the drop time or improving the landing accuracy?

Conclusion

Draft your reply to the company that hired you. You may use an informal fax format, or the more formal memo format. Be sure to address their concerns. As you prepare your response, pay particular attention to the answers to the six questions.

DISCOVERY FILE

Three Laws for the Price of One

Do you want to experience all three of Newton's laws of motion for the price of one ride? Try bumper cars!

What happens when you run your bumper car into another person's bumper car? Your car stops, but your body lurches forward. That's inertia at work—Newton's first law. Your body continues in motion until it encounters a force to stop it.

If you drive slowly and lightly tap another car, the other car only moves a little bit. At higher speeds, your moving bumper car packs a real wallop. You become a force in motion! When you hit another car, the force of the hit causes it to accelerate away from you. These collisions demonstrate the relationships among force, mass, and acceleration—Newton's second law.

When your bumper car smacks into a bumper car that is just sitting there, your car exerts a force on the sitting car, sending it moving. The sitting car exerts an equal force on your car that sends it moving, too. This is Newton's third law—action and reaction.

On your next bumper car ride, enjoy your experience with

IN THE NEWS

Disney magic at work in Europe

By Martha T. Moore
USA TODAY

COMPANY SPOTLIGHT

A DAILY LOOK AT A COMPANY, INDUSTRY OR MARKET TREND

Walt Disney's sleeping beauty is finally waking up. Euro Disney, the troubled theme park complex outside Paris, reported a profit Tuesday for the first time since opening in 1992.

That's good news for Disney, which holds a 39% stake in Euro Disney and reports its quarterly earnings today. They're expected to be about 55 cents a share, up from 49 cents a year ago.

Boosted by higher attendance and a new ride, Space Mountain, Euro Disney reported a quarterly profit of 170 million French francs ($35.3 million) the second quarter, vs. a loss of 546 million francs ($113.5 million) the same period last year. Revenue was up 17% to $283 million.

The news sent Euro Disney's stock up 1.15 francs (24 cents) to 17.45 francs ($3.63) in Paris. In New York, Disney shares closed at $55⅝, up ¾.

"We certainly have a chance to break even in 1995," a year ahead of schedule, says Chief Operating Officer Steve Burke. Analyst Marc St. John Webb of ING Bourse in Paris predicts Euro Disney could earn $31 million for the year. Less aggressive analysts predict a $10.4 million profit.

To make it into the black, Euro Disney has overhauled virtually every aspect of its operation, including its name. The theme park is now called Disneyland Paris. Hotel, restaurant and merchandise prices have been cut, and entrance prices were slashed 22% in April, to $41 from $52 for a one-day adult ticket. The company also cut costs by about $100 million last year. And it has added 10 attractions. But the company is still struggling to get visitors to spend more on food and souvenirs. And plans for a second, adjoining theme park — which would improve revenue by lengthening the average visit — are still up in the air. "We need to put a few more good quarters together before we would be in a position to take that off hold," Burke says.

In a financial restructuring last summer, Euro Disney's banks agreed to suspend interest payments on the company's $3.1 billion debt until 1998. Disney also will not collect royalties or management fees until then.

Euro Disney's results are unlikely to affect Disney's earnings, analysts say. "When you've got 530 million shares, it takes a lot of performance at Euro Disney to move (Disney stock) more than a penny or two," says Disney analyst Jeffrey Logsdon of The Seidler Cos.

More likely to boost Disney's earnings are higher theme park attendance and strong consumer product sales. Revenue from films is expected to be weaker, analysts say, compared with 1994's successful *Return of Jafar* video. "We will have *Pocahontas* (vs.) *The Lion King* issues, but that's a bigger deal in September," when this quarter's earnings are released, says analyst Sharon Williams of C.J. Lawrence Deutsche Bank Securities.

Product sales key to earnings

Walt Disney (DIS)	'93	'94	'95 est.	'96 est.
Revenue (billions)	$8.5	$10.1	$11.7	$12.3
Net income (billions)	$0.30	$1.11	$1.37	$1.60
Earnings per share	$0.55	$2.04	$2.60	$3.00

Hq: Burbank, Calif. Exch: NYSE Employees: 65,000
Div./yld.: $0.36 / 0.65% P-E: 19 Shares: 521 million
52-week high/low: $60 / $37¾ Tues. price: $55¾, +¾

Earnings, revenue estimates: Merrill Lynch
P-E based on estimated 1995 earnings.
Source: USA TODAY research

USA TODAY, 26 JULY, 1995