

Activity 5

Run and Jump



GOALS

In this activity you will:

- Understand the definition of acceleration.
- Understand meters per second per second as the unit of acceleration.
- Use an accelerometer to detect acceleration.
- Use an accelerometer to make semiquantitative comparisons of accelerations.
- Distinguish between acceleration and deceleration.



What Do You Think?

The men's high jump record is over 8 feet.

- **Pretend that you have just met somebody who has never jumped before. What instructions could you provide to get the person to jump up (that is, which way do you apply the force)?**

Record your ideas about this question in your *Active Physics* log. Be prepared to discuss your responses with your small group and the class.



For You To Do

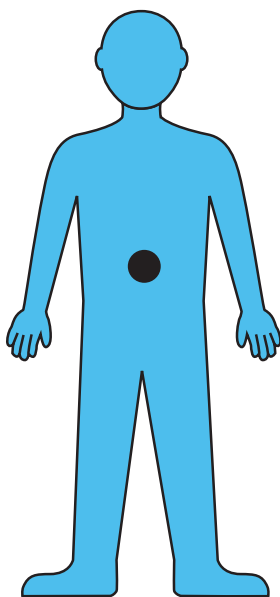
1. Carefully stand on a skateboard or sit on a wheeled chair near a wall. By touching only the wall, not the floor, cause yourself to move away from the wall to “coast” across the floor. Use words and diagrams to record answers to the following questions in your log:

- a) When is your motion accelerated? For what distance does the accelerated motion last? In what direction do you accelerate?



Physics Words

Newton's Third Law of Motion: forces come in pairs; the force of object A on object B is equal and opposite to the force of object B on object A.



- b) When is your motion at constant speed? Neglecting the effects of friction, how far should you travel? (Remember Galileo's Principle of Inertia when answering this question.)
 - c) Newton's Second Law, $F = ma$, says that a force must be active when acceleration occurs. What is the source of the force, the push or pull, that causes you to accelerate in this case? Identify the object that does the pushing on your mass (body plus skateboard) to cause the acceleration. Also identify the direction of the push that causes you to accelerate.
 - d) Obviously, you do some pushing, too. On what object do you push? In what direction?
 - e) How do you think, on the basis of both amount and direction, the following two forces compare?
 - The force exerted by you on the wall
 - The force exerted by the wall on you
2. Do a "thought experiment" about the forces involved when you are running or walking on a horizontal surface. Use words and sketches to answer the following questions in your log:
- a) With each step, you push the bottom surface of your shoe, the sole, horizontally backward. The force acts parallel to the surface of the ground, trying to scrape the ground in the direction opposite your motion. Usually, friction is enough to prevent your shoe from sliding across the ground surface.
 - b) Since you move forward, not rearward, there must be a force in the forward direction that causes you to accelerate. Identify where the forward force comes from, and compare its amount and direction to the rearward force exerted by your shoe with each step.
 - c) Would it be possible to walk or run on an extremely slippery skating rink when wearing ordinary shoes? Discuss why or why not in terms of forces.
3. Think about the vertical forces acting on you while you are standing on the floor.
- a) Copy the diagram of a person at left in your log.

- b) Identify all the vertical forces. Use an arrow to designate the size and direction of the force. Draw the forces from the dot.
 - c) How can you be sure that the force with which you push on the floor and the floor pushes on you are equal?
4. Set up a meter stick with a few books for support as shown.



5. Place a washer in the center of the meter stick.

- a) In your log, record what happens.
6. Remove the washer and replace it with 100 g (weight of 100 g = 1.0 N). Continue to place 1.0 N weights on the center of the meter stick. Note what happens as you place each weight on the stick.
- a) Measure the deflection of the meter stick for each 1.0 N of weight and record the values for these deflections.
 - b) How does the deflection of the meter stick compare to the weight it is supporting? In your log, sketch a graph to show this relationship.
 - c) Write a concluding statement concerning the washer and the deflection of the meter stick.



Do not exceed
10 N of weight.

PHYSICS TALK

Newton's Third Law of Motion

Newton's **Third Law of Motion** can be stated as:

For every applied force, there is an equal and opposite force.

If you push or pull on something, that something pushes or pulls back on you with an equal amount of force in the opposite direction. This is an inescapable fact; it happens every time.





Reflecting on the Activity and the Challenge

According to Newton's Third Law, each time an athlete acts to exert a force on something, an equal and opposite force happens in return. Countless examples of this exist as possibilities to include in your video production. When you kick a soccer ball, the soccer ball exerts a force on your foot. When you push backward on the ground, the ground pushes forward on you (and you move). When a boxer's fist exerts a force on another boxer's body, the body exerts an equal force on the fist. Indeed, it should be rather easy to find a video sequence of a sport that illustrates all three of Newton's Laws of Motion.



Physics To Go

1. When an athlete is preparing to throw a shot put ball, does the ball exert a force on the athlete's hand equal and opposite to the force the hand exerts on the ball?
2. When you sit on a chair, the seat of the chair pushes up on your body with a force equal and opposite to your weight. How does the chair know exactly how hard to push up on you—are chairs intelligent?
3. For a hit in baseball, compare the force exerted by the bat on the ball to the force exerted by the ball on the bat. Why do bats sometimes break?
4. Compare the amount of force experienced by each football player when a big linebacker tackles a small running back.
5. Identify the forces active when a hockey player "hits the boards" at the side of the rink at high speed.
6. Newton's Second Law, $F = ma$, suggests that when catching a baseball in your hand, a great amount of force is required to stop a high-speed baseball in a very short time interval. The great amount of force is needed to provide the great amount of deceleration required. Use Newton's Third Law to explain why baseball players prefer to wear gloves for catching high-speed baseballs. Use a pair of forces in your explanation.

7. Write a sentence or two explaining the physics of an imaginary sports clip using Newton's Third Law. How can you make this description more exciting so that it can be used as part of your sports voice-over?
8. Write a sentence or two explaining the concept that a deflection of the ground can produce a force. How can you make this description more exciting so that it can be used as part of your sports voice-over?

Stretching Exercises

Ask the manager of a building that has an elevator for permission to use the elevator for a physics experiment. Your teacher may be able to help you make the necessary arrangements.



1. Stand on a bathroom scale in the elevator and record the force indicated by the scale while the elevator is:
 - a) At rest.
 - b) Beginning to move (accelerating) upward.
 - c) Seeming to move upward at constant speed.
 - d) Beginning to stop (decelerating) while moving upward.
 - e) Beginning to move (accelerating) downward.
 - f) Seeming to move downward at constant speed.
 - g) Beginning to stop (decelerating) while moving downward.
2. For each of the above conditions of the elevator's motion, the Earth's downward force of gravity is the same. If you are accelerating up, the floor must be pushing up with a force larger than the acceleration due to gravity.
 - a) Make a sketch that shows the vertical forces acting on your body.
 - b) Use Newton's Laws of Motion to explain how the forces acting on your body are responsible for the kind of motion—at rest, constant speed, acceleration, or deceleration—that your body has.

