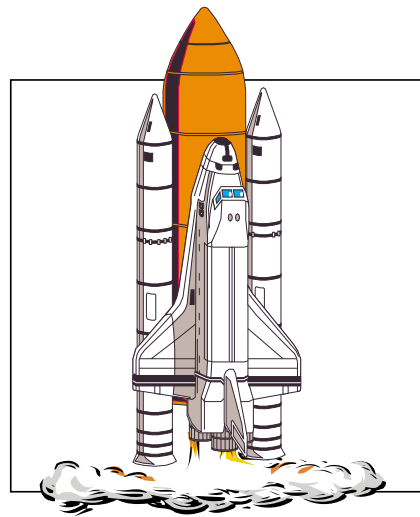
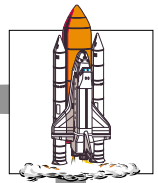


# Unit 14: Forces and Motion



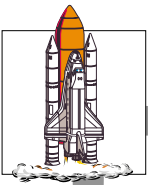




## Vocabulary

*Study the vocabulary words and definitions below.*

- acceleration** ..... any change in speed or direction
- balanced** ..... when opposing forces are equal and do not cause movement
- force** ..... any push or pull
- friction** ..... a type of resistance caused when one surface touches another surface
- gravity** ..... the attraction of matter toward another body of matter  
*Example: Earth's gravity holds us on its surface.*
- inertia** ..... a property of matter by which an object keeps its present state of motion unless acted upon
- laws of motion** ..... the laws that state the relationship between force and motion
- lubrication** ..... the greasing of surfaces that rub against each other in order to reduce friction



**mass** ..... the amount of matter in a substance

**motion** ..... movement of an object from one place to another; any change in location or alignment

**newton** ..... the Systeme Internationale (SI) unit of force; it is abbreviated as N

**resistance** ..... any force that prevents or slows down motion

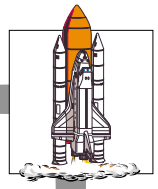
**speed** ..... the distance an object moves in a certain amount of time

**Systeme Internationale (SI)** ..... the international system of measurement that includes metrics for distance, mass, and volume, and the Celsius scale for units of temperature

**unbalanced** ..... when one force overpowers another force; the forces are not equal; causes movement

**velocity** ..... speed in a definite direction

**weight** ..... the measure of the force of gravity



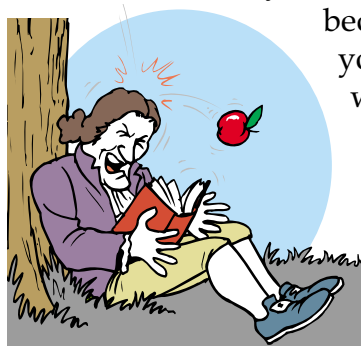
## Introduction

You have learned that **force** is any push or pull on an object. Force does not always cause an object to move. Press down as hard as you can on your desk. The desk does not move. That's because your force is equal to the force of the desk pushing against your hand. When forces are equal, they are **balanced** and do not cause movement. Forces on an object are not always equal. One force can overpower another force. The force of two horses pulling one end of a rope would overpower a man pulling on the other end of the rope. This is an example of **unbalanced** forces. Unbalanced forces cause an object to move. In this unit, forces and motion will be discussed.

## Gravity

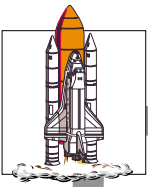
There are many different kinds of forces. **Gravity** is the force that attracts any two bodies with mass toward each other. Earth pulling on an object is gravity. About 300 years ago, Isaac Newton explained the way the force of gravity works. He stated that the force of gravity on an object depends on the mass of the object and how far the object is from Earth. Remember that **mass** is how much there is of a material. This means that **weight** is based on mass. As mass increases, the force due to gravity increases. As distances increases, however, the force due to gravity decreases in proportion to the square of the distance.

Weight is the measure of the force of gravity. As you travel away from Earth, your mass will not change, but your weight will. This is because of the way gravity behaves. Every time you double your distance from Earth, your weight becomes one fourth what it was. This is



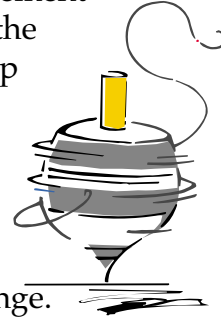
*Sir Isaac Newton*

because the force acting on you grows weaker as you move away from it. On the moon, you would weigh  $\frac{1}{6}$  what you do on Earth. This is because the moon has only  $\frac{1}{6}$  of Earth's mass. The result is it has less force to pull on you. In the **Systeme Internationale (SI)** there is a special unit to measure force. This unit is called a **newton** or **N**. Of course, it was named after Sir Isaac Newton, who first described force.



## Motion

Forces are responsible for motion. **Motion** is simply a movement of an object from one place to another. Motion can also be the change in direction or alignment of an object. Think of a top spinning on a desk. As it spins, it may not move anywhere across the desk. It still has motion, though, because it is constantly changing directions. Other terms are needed to help us understand motion. **Speed** tells us the distance an object moves in a certain amount of time. **Velocity** is speed in a definite direction. Speed and direction may change. Any change in either speed or direction is called **acceleration**.

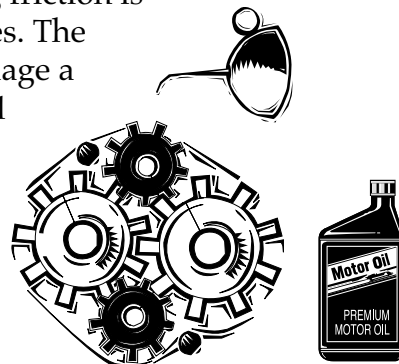


## Friction

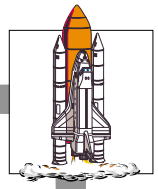
There are also forces that stop or slow down motion. Any force that prevents or slows down motion is called **resistance**. Push a box across the floor. Let go. It may move a little way and then stop. Why didn't the box keep moving? Friction made it stop. **Friction** is a type of resistance caused when one surface touches another surface. Friction is a force that makes objects slow down. Whenever we try to move something, friction pushes against it. The movement of objects through air causes a type of friction. Airplanes and cars are shaped so they can overcome some of the friction caused by air.

Friction produces heat. What happens if you drag a piece of wood across asphalt? It feels warm to the touch. Car tires heat up during a trip because of friction. The higher the friction, the greater the amount of heat produced. Rough surfaces produce more friction than smooth surfaces.

The force of friction can be reduced. Reducing friction is important to the reliable operation of machines. The friction caused by its moving parts could damage a machine. **Lubrication** reduces this friction. Oil and grease are used on surfaces that rub against each other. This kind of lubrication is common in cars, bicycles, lawn mowers, and gasoline engines. The use of rollers and ball bearings will also reduce friction. Think about pushing the box across the floor. It would be easier to move it if you put rollers between the floor and the box.



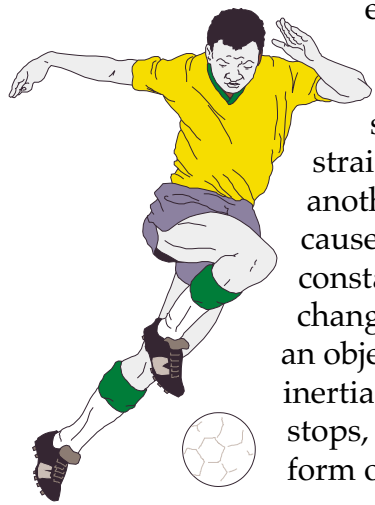
*Oil is used as a lubrication to reduce friction on moving parts of machines.*



Friction can be a helpful force. Without it, objects would slide around. Walking would be difficult. Imagine walking on ice. You might need to increase the friction between your feet and the ice to keep from falling. On the other hand, you could reduce the friction by putting on skates. Could you go faster on skates or on foot?

## Laws of Motion

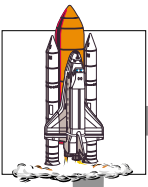
Sir Isaac Newton developed three basic **laws of motion** that explain the relationship between force and motion. His *first law of motion* states that



every object tends to remain at rest or move in a straight line until an outside force acts on it. For example, a soccer ball will stay still until someone kicks it. Once kicked, it will travel in a straight line unless another player hits it or it hits another object. **Inertia** is the property of matter that causes the velocity or speed of an object to be constant as long as there is no outside force to change that speed. That is to say that inertia means an object tends to keep its present state of motion. The inertia of an object is related to its mass. When a car stops, your body continues to move forward. This form of inertia can be overcome by using seat belts.

The *second law of motion* explains how speed and force are related. It states that the acceleration of an object is set by the size of the force acting on it. This is easy to understand. A strong force will move an object faster than a weak force. The direction of the force will also affect the object. Picture two men trying to move a refrigerator. If they push in the same direction, the refrigerator will move. If six men try to move the refrigerator, it will move faster. What would happen if three men pushed from the front and three men pushed from the side? The direction of the refrigerator would change. A part of this law also states that a large mass will need a large force to make it follow a curved path. A moving car requires a large force to keep it on a curved road.

Newton also discovered that forces do not exist alone. His *third law of motion* explains that for every action, there is an equal and opposite reaction. This is not difficult to understand. You know that gravity exerts a force on you. It pulls you toward Earth. Your weight is the "equal, but opposite" force that pushes down on Earth.



Sending astronauts into space is possible because of our understanding of the laws of force and motion. Car and airplane designs are also affected by these laws.

## Summary

Unbalanced forces cause motion. Friction is a form of resistance that slows objects down. Gravity is the force that pulls an object to Earth. Sir Isaac Newton developed three laws that explain how force and motion are related.

### Newton's 3 Laws of Motion



The *first law of motion* states that every object tends to remain at rest or move in a straight line until an outside force acts on it.

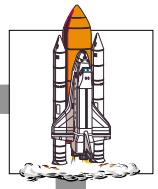


The *second law of motion* states that the acceleration of an object is set by the size of the force acting on it.



The *third law of motion* states that for every action, there is an equal and opposite reaction.

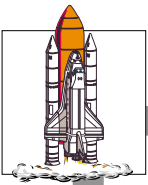




## Practice

*Circle the letter of the correct answer.*

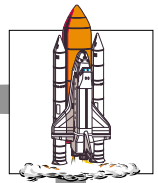
1. Motion is caused by \_\_\_\_\_ .
  - a. gravity
  - b. resistance
  - c. inertia
  - d. force
  
2. Forces that slow or stop motion are called \_\_\_\_\_ .
  - a. gravity
  - b. resistance
  - c. inertia
  - d. force
  
3. One type of resistance is \_\_\_\_\_ .
  - a. lubrication
  - b. motion
  - c. inertia
  - d. friction
  
4. Tires on the road show how friction produces \_\_\_\_\_ .
  - a. lubrication
  - b. heat
  - c. gravity
  - d. force
  
5. Friction may be reduced with \_\_\_\_\_ .
  - a. lubrication
  - b. resistance
  - c. gravity
  - d. force



6. \_\_\_\_\_ developed the three laws of motion.
- a. Newton
  - b. Galileo
  - c. Lavoisier
  - d. Olivier
7. Seat belts help to overcome \_\_\_\_\_ .
- a. gravity
  - b. resistance
  - c. inertia
  - d. motion

*Match each example of a **law of motion** with the correct law of motion. Write the letter on the line provided.*

- |  |                                  |
|--|----------------------------------|
| _____ 8. the footprint left in sand as gravity pulls against you | A. 1 <sup>st</sup> law of motion |
| _____ 9. a soccer ball at rest                                   | B. 2 <sup>nd</sup> law of motion |
| _____ 10. a water skier rounding a curve                         | C. 3 <sup>rd</sup> law of motion |

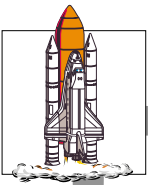


## Practice

Use the list above each section to complete the statements in that section. One or more terms will be used more than once.

|           |           |            |                  |            |
|-----------|-----------|------------|------------------|------------|
| decreased | friction  | move       | pull             | unbalanced |
| Earth     | gravity   | movement   | push             | weight     |
| equal     | increases | N          | resistance       |            |
| far       | mass      | newton (N) | Sir Isaac Newton |            |

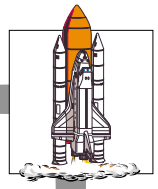
1. Force is any \_\_\_\_\_ or \_\_\_\_\_ on an object.
2. Balanced forces are \_\_\_\_\_ and do not cause \_\_\_\_\_.
3. If one force overpowers another force, we would say that the forces are \_\_\_\_\_.
4. Unbalanced forces cause an object to \_\_\_\_\_.
5. \_\_\_\_\_ is the force that pulls objects with mass toward one another.
6. About 300 years ago, \_\_\_\_\_ described how gravity worked.
7. Isaac Newton stated that the strength of gravity on an object depends on the \_\_\_\_\_ of the object and how \_\_\_\_\_ the object is from \_\_\_\_\_.



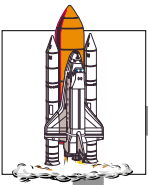
8. As mass increases, the force of gravity \_\_\_\_\_, but as distance is increased, the force of gravity is \_\_\_\_\_ proportional to the square of the distance.
9. \_\_\_\_\_ is the measure of the force of gravity.
10. In SI, the unit to measure force is called a \_\_\_\_\_.
11. The abbreviation for newton is \_\_\_\_\_.
12. Any force that prevents or slows down motion is called \_\_\_\_\_.
13. \_\_\_\_\_ is a type of resistance caused when one surface touches another surface.

|                     |                |                    |                  |
|---------------------|----------------|--------------------|------------------|
| <b>acceleration</b> | <b>faster</b>  | <b>lubrication</b> | <b>slow down</b> |
| <b>action</b>       | <b>force</b>   | <b>reaction</b>    | <b>speed</b>     |
| <b>direction</b>    | <b>heat</b>    | <b>rough</b>       | <b>three</b>     |
| <b>do not</b>       | <b>inertia</b> | <b>size</b>        |                  |

14. Friction is a force that makes objects \_\_\_\_\_.
15. Friction produces \_\_\_\_\_.
16. \_\_\_\_\_ surfaces produce more friction than smooth surfaces.
17. \_\_\_\_\_ will reduce friction.
18. Sir Isaac Newton developed \_\_\_\_\_ basic laws that explain the relationship between force and motion.



19. His first law of motion stated that every object tends to remain at rest or move in a straight line, until an outside \_\_\_\_\_ acts on it.
20. \_\_\_\_\_ is the idea that an object tends to keep its present state of motion.
21. Newton's second law of motion explains how \_\_\_\_\_ and \_\_\_\_\_ are related.
22. Newton's second law of motion states that the \_\_\_\_\_ of an object is set by the \_\_\_\_\_ of the force acting on it.
23. A strong force will move an object \_\_\_\_\_ than a weak one.
24. The \_\_\_\_\_ of the force will also affect the object.
25. Newton also discovered that forces \_\_\_\_\_ exist alone.
26. Newton's third law of motion explains that for every \_\_\_\_\_, there is an equal and opposite \_\_\_\_\_.



## Lab Activity

### Facts:

- Friction is a force.

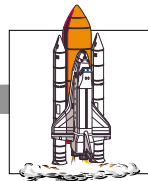
### Investigate:

- You will determine that lubrication will reduce friction.

### Materials:

- block of wood
- 2 screws
- screwdriver
- bar of soap

1. Use the screwdriver to drive a screw into a block of wood.
  - a. Was work done? \_\_\_\_\_
  - b. Did the screw move? \_\_\_\_\_
  - c. What force made it difficult to move the screw?  
\_\_\_\_\_
  - d. Can this force be reduced? \_\_\_\_\_
2. Coat the second screw with soap. Use the screwdriver to drive the screw into the block of wood.
  - a. Was it easier or harder to drive the second screw into the wood?  
\_\_\_\_\_



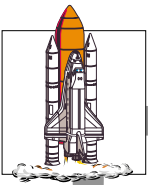
b. What force was reduced? \_\_\_\_\_

c. What substance was applied to the screw to reduce the force?

\_\_\_\_\_

d. The soap acted as a \_\_\_\_\_.

e. Lubrication will reduce \_\_\_\_\_.



## Practice

Read each problem below and answer the questions that follow.

1. You have a ring stuck on your finger. How can you get it off? What force will you overcome?

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2. Why do objects of the same mass weigh less on the moon than on the Earth?

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3. State which law of motion applies in each of the following examples. Draw a picture of each example.

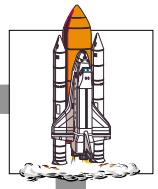
When you place a skateboard on a flat, level surface, it will not move until you or some other force move it.

Law: \_\_\_\_\_

As the boy jumped from the canoe into the water, the canoe backed away from the boy.

Law: \_\_\_\_\_





On the first trip, one girl pulled a large crate up the hill. On the second trip, three girls pulled the same crate up the hill. Which trip was easier? Why?

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Law: \_\_\_\_\_

4. If you have a mass of 100 kg, then the force of gravity on Earth is 980 N. Would you weigh less flying in an airplane? The sun has more mass than the Earth. If you could stand on the surface of the sun, would you weigh more? Explain your answers.

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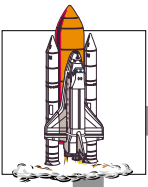
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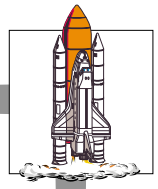
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## Practice

Match each definition with the correct term. Write the letter on the line provided.

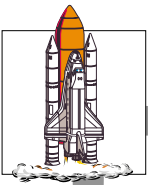
- |       |   |                     |
|-------|---|---------------------|
| _____ | 1. any push or pull on an object  | A. balance force    |
| _____ | 2. the laws that state the relationship between force and motion                      | B. force            |
| _____ | 3. when forces are equal and do not cause movement                                    | C. friction         |
| _____ | 4. the idea that an object keeps its present state of motion                          | D. gravity          |
| _____ | 5. the force of Earth's gravity pulling on an object                                  | E. inertia          |
| _____ | 6. when one force overpowers another force; the forces are not equal; causes movement | F. laws of motion   |
| _____ | 7. the SI unit to measure force   | G. lubrication      |
| _____ | 8. the attraction between any two objects with mass                                   | H. N                |
| _____ | 9. abbreviation for newton  | I. newton           |
| _____ | 10. a type of resistance caused when one surface touches another surface              | J. resistance       |
| _____ | 11. any force that prevents or slows down motion                                      | K. unbalanced force |
| _____ | 12. the greasing of surfaces that rub against each other in order to reduce friction  | L. weight           |



## Practice

*Answer the following using short answers.*

1. Are all forces equal? \_\_\_\_\_
2. Can one force overpower another force? \_\_\_\_\_
3. What term do we give to forces that are equal? \_\_\_\_\_
4. What term do we give to forces that are not equal?  
\_\_\_\_\_
5. What name is given to the force of Earth pulling on an object?  
\_\_\_\_\_
6. What is the special unit in the metric system that measures force?  
\_\_\_\_\_
7. Are forces responsible for motion? \_\_\_\_\_
8. What do we call any force that prevents or slows down motion?  
\_\_\_\_\_
9. What is the type of resistance caused when one surface touches another surface?  
\_\_\_\_\_
10. Is friction a force? \_\_\_\_\_
11. Do rough surfaces produce more friction than smooth surfaces?  
\_\_\_\_\_



12. How can the force of friction be reduced? \_\_\_\_\_

\_\_\_\_\_

13. What are two substances used as lubricants? \_\_\_\_\_

\_\_\_\_\_

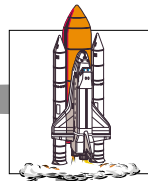
14. Who developed the three basic laws of motion? \_\_\_\_\_

\_\_\_\_\_

15. What is inertia? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



## Practice

Write the three laws of motion.

1. First law of motion: \_\_\_\_\_

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2. Second law of motion: \_\_\_\_\_

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3. Third law of motion: \_\_\_\_\_

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