



SCIENCE

STUDENT BOOK

▶ **8th Grade | Unit 8**

SCIENCE 808

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Machines 2

Introduction

The use of tools is mentioned throughout the Bible. Noah used tools to build the ark that saved mankind from the flood waters. Tools have helped mankind build altars and temples to worship the Lord. God has given human beings the skills to develop and use tools. Tools are simple machines. In this LIFEPAAC® you will study six simple machines and how humans use them.

The development of machines encouraged mankind to build, to invent, to travel, and to work. People can do more work with machines than they can without.

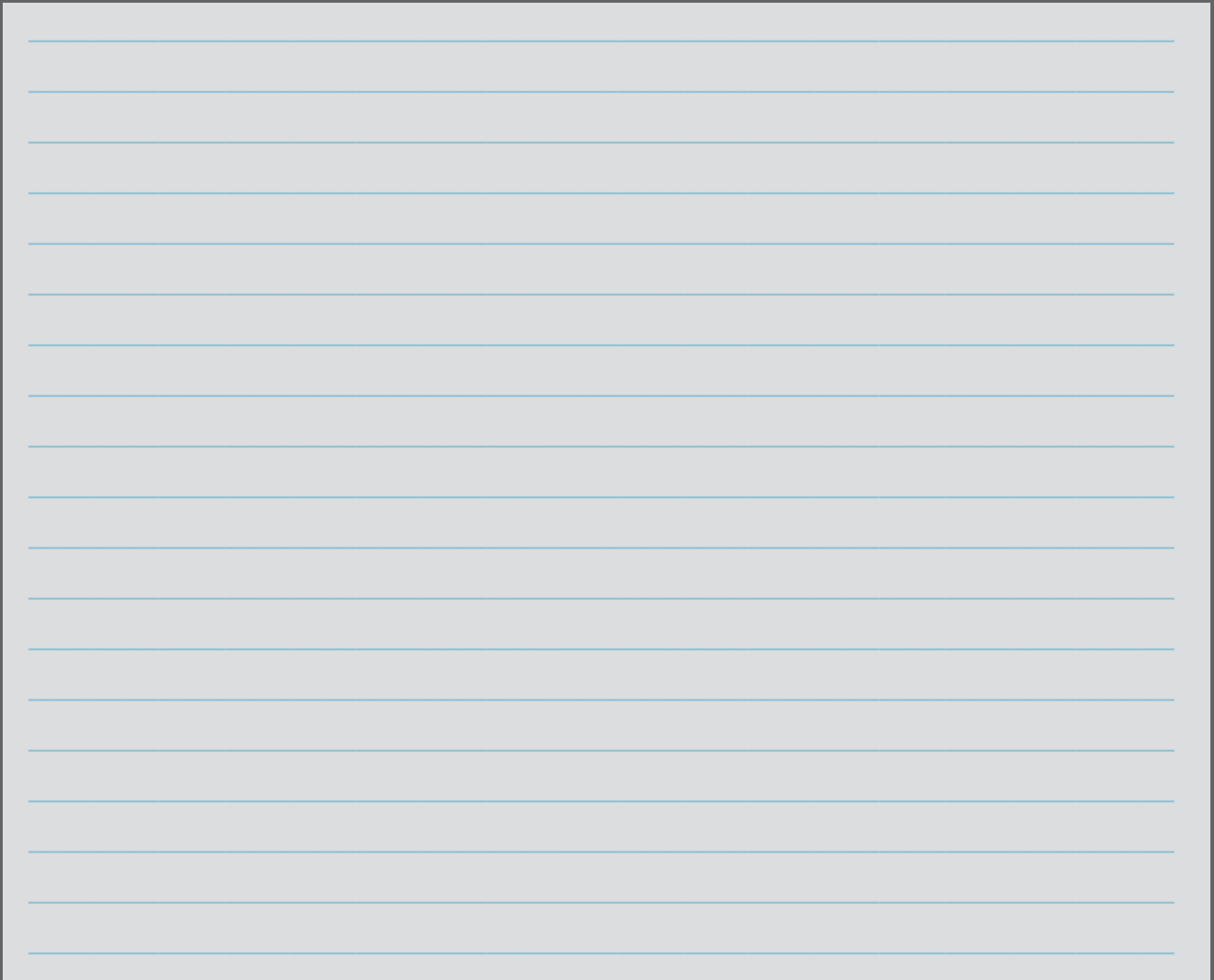
Machines are not as useful as they might be because friction makes them less efficient. Friction causes them to wear out, to slow down, and to stop. The work that mankind was designed to do is slowed down by the friction of bad relationships between people.

Objectives

Read these objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAAC. When you have finished this LIFEPAAC, you should be able to:

1. Define friction and describe its effects.
2. Identify three kinds of friction.
3. Name three ways to reduce friction.
4. Calculate the coefficient of friction.
5. Identify three classes of levers.
6. Define and calculate the mechanical advantage and efficiency of a lever.
7. List the uses of the wheel and axle, pulley, and gears.
8. Calculate the mechanical advantage of the wheel and axle and pulleys.
9. Identify the uses of the inclined plane, wedge, and screw.
10. Calculate the mechanical advantage of the inclined plane, wedge, and screw.

Survey the LIFE PAC. Ask yourself some questions about this study and write your questions here.

A large rectangular area with horizontal blue lines for writing. The lines are evenly spaced and extend across the width of the box, providing a template for handwritten notes or questions.

1. FRICTION

In the winter when the sidewalks are covered with snow and ice, we sand them to increase the **friction** between the steps and our feet. We apply oil to engines and motors to reduce the friction between moving parts. Without

friction even walking would be impossible; but friction causes engines to wear out. Friction is both helpful and harmful. In this section you will study the forces of friction, the types of friction, and some ways to reduce friction.

SECTION OBJECTIVES

Review these objectives. When you have completed this section, you should be able to:

1. Define friction and describe its effects.
2. Identify three kinds of friction.
3. Name three ways to reduce friction.
4. Calculate the coefficient of friction.

VOCABULARY

Study these words to enhance your learning success in this section.

coefficient (kō u fish' unt). A ratio used to calculate the value of a quantity under different conditions.

fluid (flü' id). Any substance, liquid or gas, that flows.

force (fôrs). A push or a pull.

friction (frik' shun). The force that resists moving one object against another.

lubricant (lü' bru kunt). Substance used to make an object slippery or smooth; commonly, oil or grease.

normal force (nôr' mul fôrs). The force that is perpendicular to the surface between two objects; the attraction of gravity for an object on a level surface.

Note: All vocabulary words in this LIFEPAAC appear in **boldface** print the first time they are used. If you are not sure of the meaning when you are reading, study the definitions given.

Pronunciation Key: hat, āge, cāre, fār; let, ēqual, tērm; it, īce; hot, ōpen, ôrder; oil; out; cup, pūt, rüle; child; long; thin; /ʒh/ for then; /zh/ for measure; /u/ represents /a/ in about, /e/ in taken, /i/ in pencil, /o/ in lemon, and /u/ in circus.

FORCES OF FRICTION

Many factors, including **friction**, slope, and material, act to change the speed of an object. For centuries people tried to invent perpetual-motion machines. Perpetual-motion machines would create their own energy and never stop working. People have not been able to invent such a machine. Friction is the **force** that always stopped them. You will study the force of friction in this section.

Definition. Friction is a force that resists motion. It occurs when a surface in motion rubs against another surface. Friction acts parallel to the surfaces that are moving against (contacting) one another and in the direction opposite to the direction of motion. Friction resists (opposes) motion.

If you put a box on the sidewalk and push it, the box moves. You have exerted a force. Friction will cause the box to stop moving after traveling a short distance. A resisting force has acted. The box will not move again unless you give it another push.

Friction is present whenever motion occurs. Car engines are designed to produce as little friction as possible. Narrow-wheeled bicycles offer less resistance to friction than other bicycles.

Causes. Friction is caused by rough surfaces rubbing together as objects move over each

other. Surfaces are polished to lessen friction as much as possible. Engineers design shapes to lessen air resistance. When two very highly polished surfaces are together, the friction between them *increases*. The explanation proposed is that atomic bonding, of a sort, exists between the two surfaces.

Uses. Friction makes walking possible. The friction between shoe and floor increases with roughness. Walking becomes easier. Imagine walking on polished ice with waxed shoes!

Vehicles use friction to slow down and stop. Brakes depend upon friction. The resistance between tire and road slows cars and trucks. Tires are designed with a tread to increase friction. Wet roads are more dangerous than dry roads because water lessens the tires' friction on the road surface. Tires are tested on wet roads to determine stopping distance and skid resistance.

Without friction any little force you exerted on an object would send you in one direction and would send the object in the opposite direction. This example illustrates Newton's Law: Every force has an equal and opposite force. In space, friction with air does not exist. When astronauts push on a spaceship, it moves one way and they move another.



Write the letter of the correct choice.

- 1.1 Tires are designed to _____ .
 a. increase friction b. decrease friction c. have no relation to friction
- 1.2 Very smooth surfaces _____ .
 a. have little or no friction b. do not need friction to move
 c. have increased friction

Complete these sentences.

- 1.3 Motion is always accompanied by _____ .
- 1.4 Friction acts _____ (parallel, perpendicular) to surfaces in contact.



Complete the activity. For each item write D if it is a desirable type of friction, or write U if it is an undesirable type of friction.

- 1.5 _____ friction between road and tires
- 1.6 _____ friction between parts of an engine
- 1.7 _____ friction between your shoes and the floor
- 1.8 _____ no friction at all

TYPES OF FRICTION

Friction forces apply mostly to solids. Gases and liquids offer resistance to motion, but they are difficult to measure and study in the classroom or laboratory. Comparison of different frictional forces is possible in the laboratory: The force needed to keep an object moving can be measured with a scale. If you pull an object with a spring scale, you find that the object requires more force to start moving than to keep moving. This force that opposes the start of motion is referred to as *starting friction*.

Sliding. *Sliding* friction is resistance to motion after the object has begun to move. Sliding

friction is dependent on the materials that make up the surfaces in contact.

In the past, farmers removed rocks from their fields by loading them on a horse-drawn flat-bed. The horses worked, and the wooden flat-bed dragged against the ground.

Sliding friction is affected very little by the speed or the surface area of the moving object. It is affected by the force that presses the surfaces together. This force is called the **normal force**. On level surfaces the normal force is the weight of the object.



Try this investigation.

These supplies are needed:

- small match box
- pebbles
- coins (pennies are best)
- string (about 24 inches long)
- small plastic bag

Follow these directions and complete the sentence. Put a check in the box when each step is completed.

- 1. Fill the match box with pebbles.
- 2. Tie the string to the box. Allow the string to hang over the edge of the table.
- 3. Tie this end of the string to the plastic bag, leaving an opening to put in coins.
- 4. Add coins one by one until the box is pulled off the table.
- 5. Count and record the number of coins.



1.9 The number of coins needed to pull the box off the table was ____ .
Do not put this activity away; you will be using it again.

Force of Friction Experiment

Rolling. Early in history most cultures discovered that rolling objects was easier than dragging them. To move a flat object, a cylindrical roller was placed beneath it. The object could then be rolled over the ground. The first rollers were probably logs. The logs had to be carried around to the front of the object after the object had passed over them. This method still involved hard work, but it was easier than

dragging the object. The friction involved in sliding an object is great; rolling friction is much less.

Roller bearings and steel rollers are used to reduce friction in moving small and large objects. House movers use steel rollers to position buildings. Ball bearings permit low friction motion in all directions and are used to reduce friction in automobile wheels, bicycle wheels, and machines.



Try this investigation.

These supplies are needed:

- all items from previous investigation.
- 8 or 10 round sticks (pencils, Tinker Toys, dowels)

Follow these directions and complete the sentence. Put a check in the box when each step is completed.

- 1. Lay the round sticks on the table about 1 inch apart and about 2 inches back from the edge of the table.
- 2. Put the match box from Activity 1.9 on the rollers farthest away from the edge.
- 3. Now add coins one by one to the bag until the box is pulled off the table.
- 4. Count and record the number of coins.

1.10 How many coins were needed to pull the box off the table? _____

1.11 Is this number less than in 1.9? _____

1.12 What is your explanation for 1.11? _____



Overcoming Friction Experiment

Fluid. Gases and liquids also offer resistance to motion. Air resists the motion of cars and airplanes. These vehicles are designed to offer the least possible *air resistance*. Boats must overcome the resistance of the water, and they have hulls shaped to lessen resistance to motion. Frictions that involve liquids and gases are examples of **fluid** friction.

We streamline cars and airplanes to reduce fluid friction. Even the rivets on an airplane increase the friction. The surfaces are as smooth as the builder can make them to reduce the friction between the airplane and the air.



Write true or false.

- 1.13 _____ Streamlining a car or boat can increase speed by decreasing friction.
- 1.14 _____ Gases and fluids do not produce friction.
- 1.15 _____ Sliding friction is affected by the weight of the object.
- 1.16 _____ Smooth surfaces can decrease fluid friction.

Complete these sentences.

- 1.17 The force needed to start an object in motion is increased by _____ friction.
- 1.18 The motion of an object being pulled over a surface is called _____ friction.
- 1.19 Ball bearings are an example of _____ friction.
- 1.20 The resistance of air to a moving object is called _____ friction.

Try this investigation.

- 1.21 Select and complete *one* of the following activities.

A. Go to the library and look at pictures of early automobiles. Compare them with the shape of present cars. Describe the differences and tell how friction may have helped to change the shape of cars.

B. Make a drawing of a car, boat, or plane that you think would offer the least resistance to fluid friction. Your drawing should be on plain white paper, 8½ x 11 in size.

C. Make a list of places in your home that friction may occur. You should have at least ten items. After each item tell if it is sliding, rolling, or fluid friction taking place.

TEACHER CHECK

_____ initials

_____ date

REDUCING FRICTION

In certain situations friction is necessary, but in other instances we wish to eliminate as much friction as possible. Many methods and combinations of methods can be used to lessen the effects of friction.

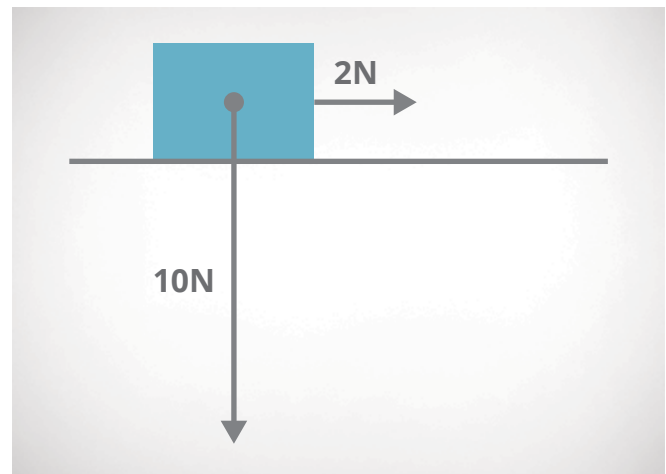
Lubrication. Years ago the wagons used to haul grain to market had wooden wheels and axles. They were heavily loaded and gave off a piercing noise as they moved across the prairie. The noise was lessened when a **lubricant**, grease, was applied to reduce the friction between the wheel and axle.

Lubrication with oil, grease, or other lubricants lessens the friction. Petroleum products have molecules that slide on each other with little resistance. Graphite is carbon with flat crystals. These crystals slide over each other easily. Graphite is a lubricant that has many specialized uses. Because it is a powder, graphite can be blown into locks to lubricate the mechanism.

Shapes. The *shape* of an object determines how much resistance it will receive as it moves over a surface. Shapes that roll across a surface, like rollers or ball bearings, have the least resistance. Aircraft, automobiles, boats, and submarines have sleek, tapering lines to permit fluids to flow over them with the least resistance.

If you try to move a variety of shapes through water, you can estimate the effectiveness of the shape by the amount of disturbance in the water. The greater the disturbance, the greater the friction.

Friction-reducing materials. *Teflon* is a substance used to coat bearings and other parts of machines when eliminating friction is important. Teflon also coats cooking utensils to eliminate sticking. Some metallic alloys reduce friction more than other alloys. A surface of lead and antimony lessens friction when used with steel.



The ratio between the force of friction and the perpendicular force is called the **coefficient** of friction.

A box weighing 10 pounds (newton) is pulled along the floor by a force of 2 pounds. What is the coefficient of friction between the floor and the box? The force pressing the surfaces together is 10 lbs. (F_n); the force required to move the box is 2 lbs. (F_f). Coefficient of friction μ (the Greek letter *mu*) is

$$\mu = \frac{F_f}{F_n} = \frac{2}{10} = 0.2$$

The coefficient of friction permits a comparison of the sliding friction of different materials.

In the preceding example, the unit of force was given as the *pound*. You know that the pound is the unit of weight, so the question comes up, “Is weight a force?” The answer is “yes” because weight results from the pull—the gravitational force—that the earth exerts on objects.

The metric system (correctly called SI) unit of force (and therefore of weight) is the *newton* (N). The newton is derived from the SI base units of length (meter), time (second), and mass (kilogram). We therefore are correct in saying that an object weighs, or exerts a force of 10 newtons (10N).



Try this investigation.

These supplies are needed:

- 2 blocks of wood
- bar of soap

Follow these directions and complete the sentence. Put a check in the box when each step is completed.

- 1. Slide the two blocks of wood over each other.
- 2. Then rub soap over the surface of each block and rub together again.

1.22 When were the wood blocks the easiest to rub together? _____



You can use this method of lubrication to keep drawers from sticking. Safety pins or straight pins that have been stuck in a bar of soap will go through fabric much easier.

Friction-Reducing Experiment



Complete these sentences.

- 1.23** The use of oil or grease to lessen friction is called _____ .
- 1.24** To lessen friction, an airplane has a streamlined _____ .
- 1.25** Lead and antimony can be used to coat steel to lessen _____ .

Complete these activities.

- 1.26** A swimmer is going to swim across the English Channel. Before entering the water, he covers his head with a smooth plastic cap. Then he covers his body with thick grease. Explain why you think these two preparations will help him while swimming.

- 1.27** A can weighing 18 newtons requires a force of 9 newtons to drag it. Calculate the coefficient of friction.



Review the material in this section in preparation for the Self Test. The Self Test will check your mastery of this particular section. The items missed on this Self Test will indicate specific areas where restudy is needed for mastery.

SELF TEST 1

Write true or false (each answer, 1 point).

- 1.01 _____ Friction and motion occur at the same time.
- 1.02 _____ Graphite crystals can be used as a lubricant.
- 1.03 _____ In space fluid friction does not exist.
- 1.04 _____ Sliding friction occurs when an object is pulled over a surface.
- 1.05 _____ Teflon is used only to prevent sticking in cooking utensils.
- 1.06 _____ Friction should always be reduced if possible.
- 1.07 _____ A fluid may be either liquid or gas.

Write the letter of the correct choice (each answer, 2 points).

- 1.08 The shape that has the least friction in air is _____ .
 a. round b. streamlined c. square d. oblong
- 1.09 To reduce friction in a roller skate wheel, we could use _____ .
 a. polished surfaces b. ball bearings
 c. a lubricant d. a, b, and c

Complete these activities (each answer, 3 points).

1.010 Give three examples of desirable friction.

- a. _____
- b. _____
- c. _____

1.011 Explain why friction is sometimes undesirable.

1.012 Give three ways friction can be reduced.

- a. _____
- b. _____
- c. _____

Describe each of these kinds of friction and give an example of where they may occur (each answer, 3 points).

1.013 sliding friction

- a. description _____
- b. example _____

1.014 rolling friction

- a. description _____
- b. example _____

1.015 fluid friction

- a. description _____
- b. example _____

Complete these calculations (each answer, 3 points).

1.016 A box weighing 18 newtons require a force of 6 newtons to drag it.

- a. What is the coefficient of friction?

The box is coated with Teflon and now requires a force of 3 newtons to drag it.

- b. What is its new coefficient of friction?

49 61	SCORE _____	TEACHER _____	initials	date
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