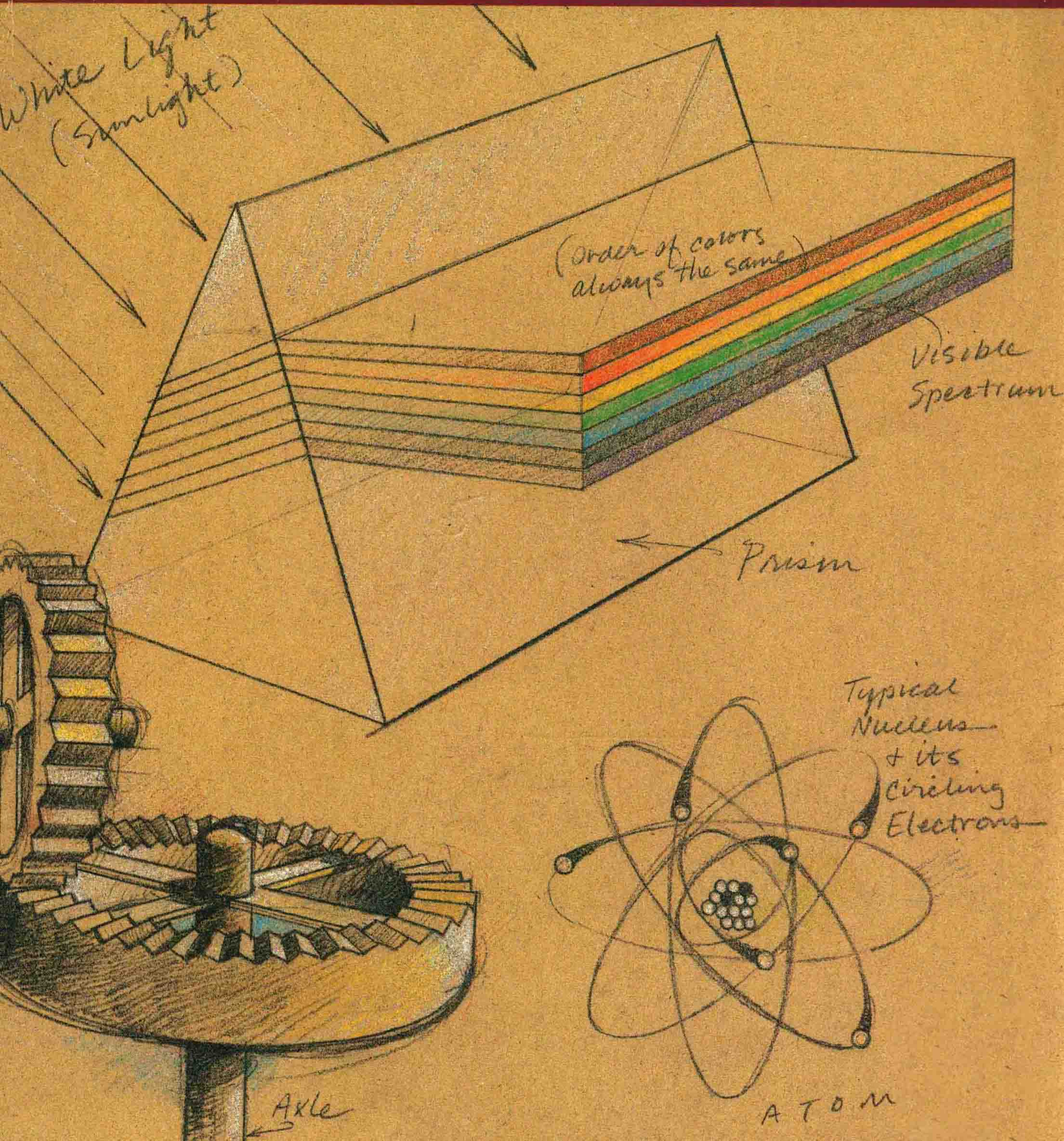
STECK-VAUGHN

BASIC SCIENCE FOR LIVING

PHYSICAL SCIENCE



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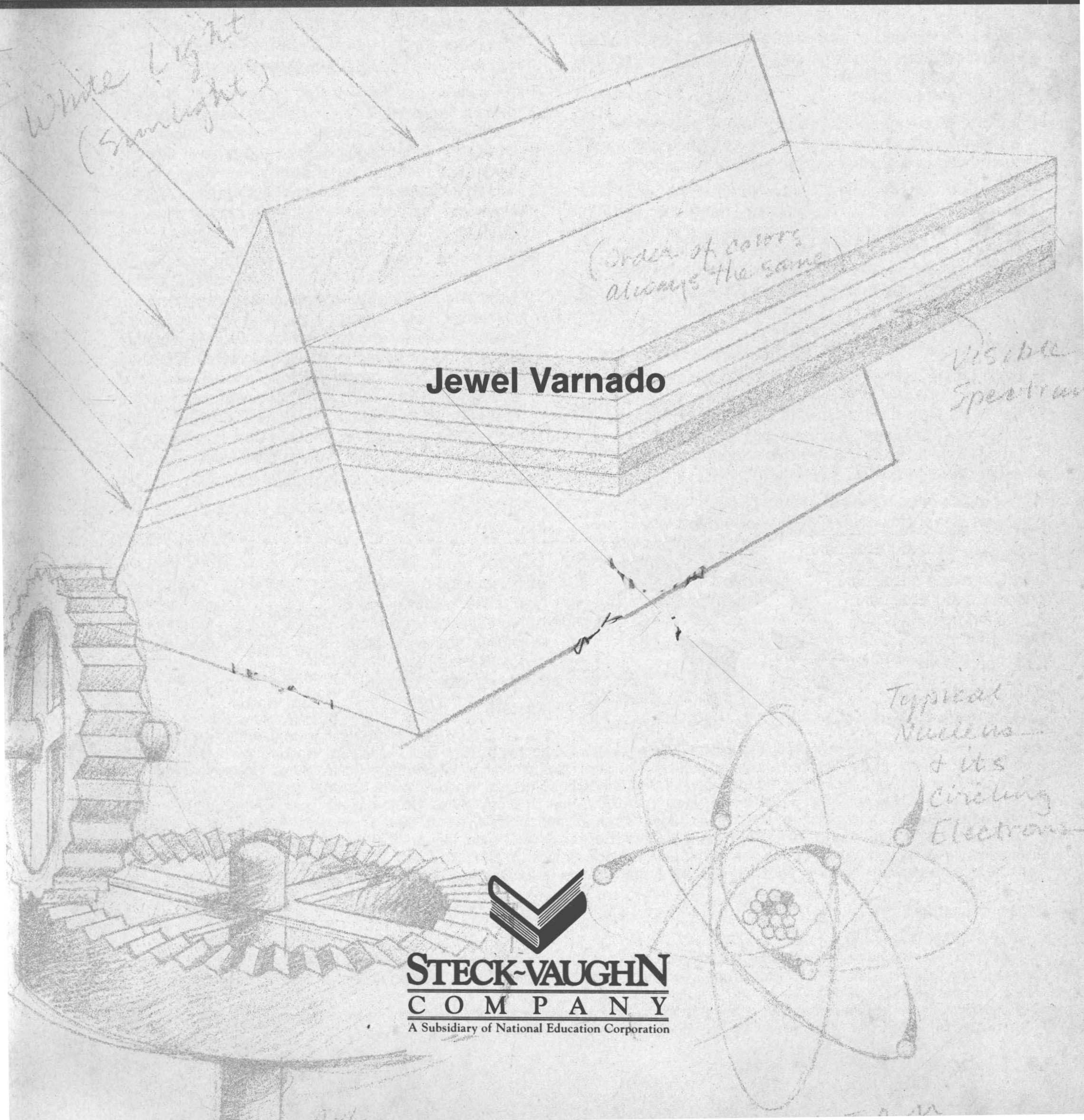

Jewel Varnado

STECK-VAUGHN
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To the Teacher and the Student

Basic Science for Living is a two-book program specially designed for students who need to learn or review the basic scientific facts covered in a general science course. In *Earth and Life Science,* and *Physical Science,* students are introduced to science concepts through an explanation of the real-life science they experience every day. Students gain a thorough understanding of scientific terms and concepts from the relevant setting in which terms and concepts are presented. Mastering science is a challenging task. Special care has been taken in preparing both the organization and content of these books to guide the student to meeting this challenge with success.

- Each worktext is written in a manner that develops a high degree of reading comprehension and vocabulary, while providing a thorough survey of basic science. The author uses a conversational style of writing and consistent method of introducing, defining, and explaining scientific terms and processes to make the content lively, informative, and relevant for both student and teacher.
- Important science terms are highlighted and defined within the text. These terms are also defined and page referenced in a glossary at the back of each book.
- In each book, scientific facts and ideas have been grouped into seven units of related knowledge. *Earth and Life Science* begins with a discussion of the universe and our planet's place in the universe, then proceeds to discuss water, air, plants, animals, the human body, and health. *Physical Science* explores force and energy, thermal energy and heat, magnetism and electricity, light, sound, matter, and radioactivity and how these properties relate to our daily lives.
- Each unit is divided into several self-contained lessons. A review at the end of every lesson comprehensively tests the lesson's content. Lesson reviews follow five consistent, standardized formats that prepare students for other types of standardized assessment tools.
- Two black dots in the left margin of each lesson review signal critical thinking questions specially prepared to challenge students to apply knowledge they have gained to new situations.
- Each unit also presents two special features to make science more relevant to students lives. An *Issues in Science* lesson points out current science-related topics that are the subject of controversy or part of a trend in general science today. A *Careers* feature at the end of each unit points out careers in which general and/or specific science knowledge is important. Each career feature also provides a bibliography of books and associations for obtaining more information about careers in the area of science being discussed.
- A Mastery Review at the end of each book provides a chance to check mastery of important concepts and gives students practice with the commonly used separate-answer-sheet format. Clearly explained directions for the review allow it to be administered by the teacher or by students themselves.
- An easy-to-use Answer Key can be found at the back of each worktext. The answer key was prepared with both teacher and student use in mind. Students working independently will find the answer key an invaluable resource for checking their mastery of each lesson's concepts as presented in the lesson review. However, the answer key is perforated to allow easy removal for use in more traditional settings.
- The *Basic Science for Living* program was designed to bring science to students in a meaningful and useful way. The clarity of presentation, self-contained lessons, timely reviews, interesting features, glossary, mastery review, and answer key facilitate learning in a variety of educational situations—traditional classroom, small group seminar, tutorial instruction, and independent-study. The current and comprehensive content of *Basic Science for Living* provides students with the knowledge essential to understanding the world in which we live—a most exciting and interesting place.

About the Author

Jewel Varnado earned her bachelor's and master's degrees in educational psychology and her Ph.D. in adult education from Florida State University. She has received the Florida Adult Education Association's Outstanding Service Award and has successfully served as an instructor and a supervisor of adult education in Florida. She is the author of several children's books, a series of high-school English books *(English: Practice for Mastery),* and an English refresher course for adults *(English Essentials).*

Acknowledgments

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ISBN 0-8114-4062-1

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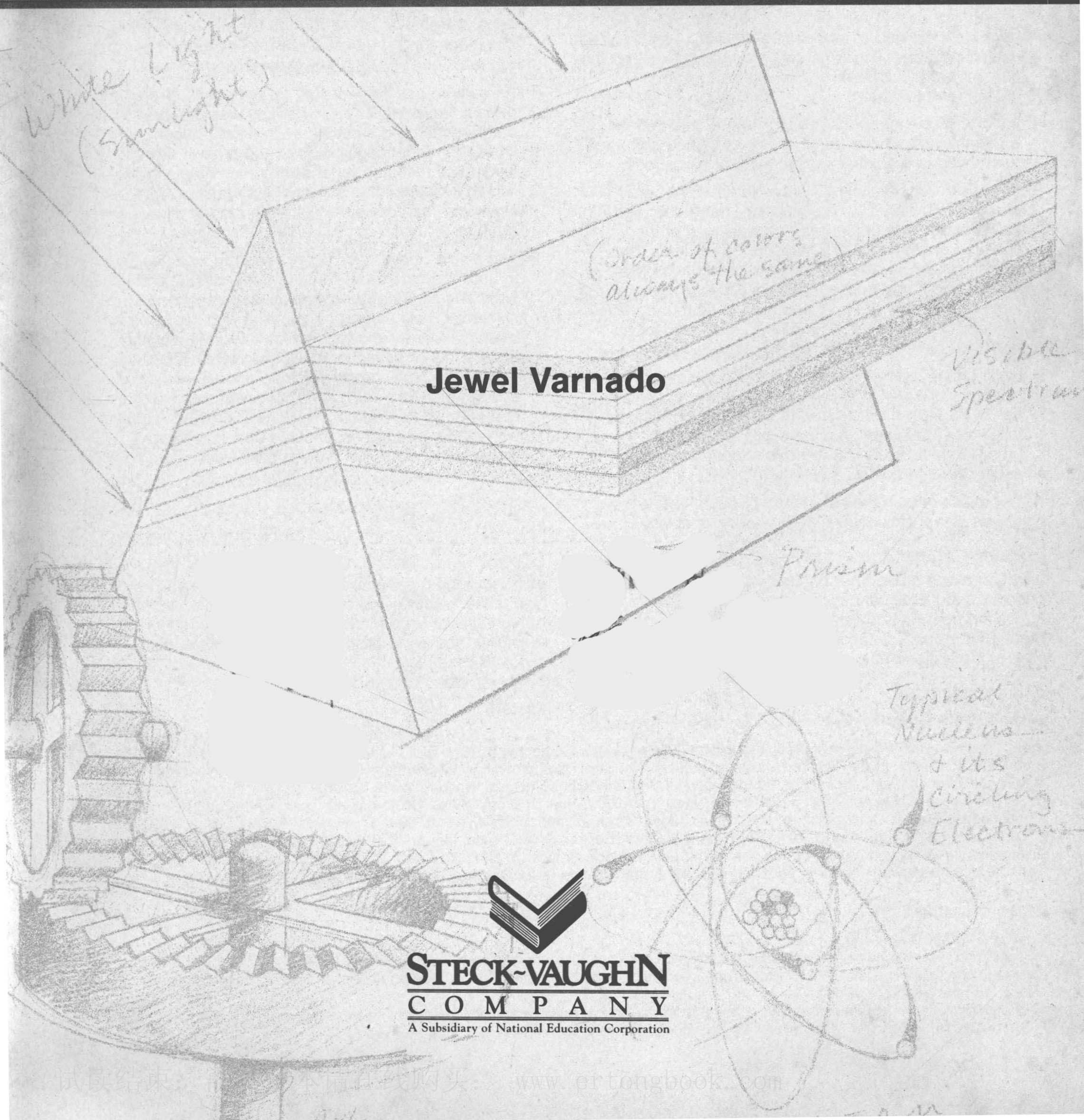

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ISBN 0-8114-4062-1

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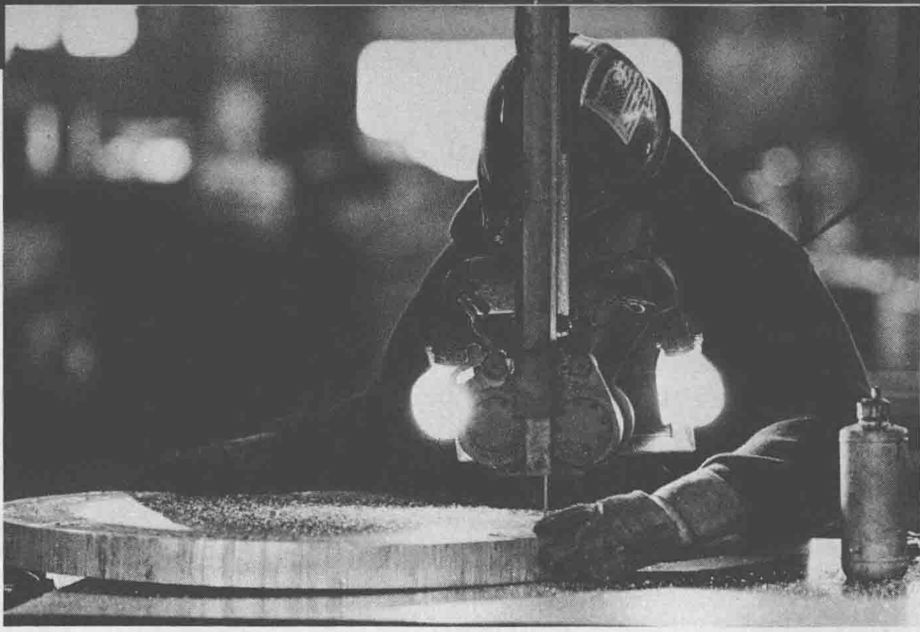
Unit One

Force and Energy



Many machines change energy into work.

Lesson 1

Energy

Scientists define **energy** as the ability to do work. An object has energy if it is able to produce a change in itself or in its surroundings. **Work** is the transfer of energy as the result of motion. If there is no motion, there is no work.

The **law of conservation of energy** states that the amount of energy in the universe is always the same. Energy cannot be created or destroyed. Energy can only be transferred, or changed, from one form into another. For example, energy transfer occurs when electrical energy is changed into radiant energy when a light bulb is switched on.

Everything has energy either because of its condition or position, or because of its motion. **Potential energy,** or stored energy, is energy available for use. There is potential energy in your muscles, in the string attached to a bow, in the gasoline in your car, and in a piece of coal. When potential energy is converted into motion, it is called **kinetic energy.** Kinetic energy appears when you move your muscles, when the bow string vibrates, when your car moves, and when the piece of coal is burned.

The kinetic energy and potential energy in moving your muscles are forms of mechanical energy. Many machines change mechanical energy into work. The motor in a power lawn mower, for example, transfers the chemical energy in its fuel into mechanical energy that moves its parts. The movement of these parts allows the mower's blades to cut grass.

There are many forms of potential energy: chemical, electrical, radiant, magnetic, thermal, and nuclear. Chemical energy is found in foods and other forms of fuel. The stored energy in food and gasoline helps our bodies and cars to move. Electrical energy helps to run the appliances in our houses. Light is one form of radiant energy. Magnetic energy is used by an electric motor. Thermal energy, which is commonly and incorrectly referred to as heat, is the total energy of all the particles that make up a substance. **Heat** is the energy transferred from an object at a higher temperature to an object at a lower temperature. Nuclear energy is potential energy provided by the nucleus of an atom.

Energy is measured in different units. All of these units can be expressed in terms of the amount of work that is done. The work done to or by an object is the force multiplied by the distance over which the force acted or, more simply, force times distance equals work. A **force** is a push or a pull that one body or object exerts on another. If you move a one-pound box a distance of one foot, how much work did you do? By multiplying one pound by one foot, the amount of work done is one foot-pound. A foot-pound is the amount of work done when a one-pound object is moved a distance of one foot. ■

Lesson Review

On the line before each statement, write the letter of the choice that best completes the statement.

______ 1. ______ is the ability to do work.
a. Force b. Energy c. Power d. Transfer

______ 2. The transfer of energy as a result of motion is ______.
a. force b. power c. work d. physical

______ 3. The law of conservation of energy states that ______.
a. all energy comes from the sun
b. energy can be created or destroyed
c. the amount of energy always changes
d. none of the above

______ 4. Energy that is available for use is ______ energy.
a. work b. potential c. kinetic d. forceful

______ 5. Energy of motion is also called ______ energy.
a. work b. potential c. kinetic d. forceful

______ 6. Chemical energy is a kind of ______ energy.
a. potential b. kinetic c. radiant d. mechanical

______ 7. ______ energy is used by an electric motor to do work.
a. Chemical b. Magnetic c. Nuclear d. Thermal

______ 8. The energy transferred from an object at a higher temperature to one at a lower temperature is ______.
a. thermal energy b. radiant energy c. magnetic energy d. heat

• ______ 9. Which of the following is an example of kinetic energy?
a. a person jogging b. an operating fan c. a moving train d. all of the above

• ______ 10. ______ is not an example of work being done.
a. A person lifting an object
b. A person winding a clock
c. A dog carrying a bone
d. A person pushing against a wall

Lesson 2

Forces and Motion

Recall that work is done to an object or by an object only if there is movement or motion. What is motion? **Motion** can be defined as a change in position. Earth rotating on its axis, the movement of a second hand on a clock, and a car slowing down at a stop sign are all examples of objects in motion.

How fast is Earth rotating on its axis? How fast is the clock hand moving? How slow is the car going? **Speed** is the rate of change of the position of an object. Speed is measured in units of distance covered in a set amount of time. Earth rotates on its axis at a speed of about 330 miles per hour. The second hand on a clock moves one position every second. A car slowing down at a stop sign may be moving at a speed of less than ten miles per hour.

Velocity refers to an object's speed and the direction in which it is moving. Velocity is measured in units of distance and time. Velocity changes if either the speed of the object or the direction of the object changes. For example, two airplanes may be traveling at 600 miles per hour, but if one is traveling east and the other is headed west, they have different velocities.

When the velocity of an object changes, the object is either accelerating or decelerating. If the velocity increases, the object is accelerating. If the velocity decreases, as is the case with the car slowing down at a stop sign, the object is decelerating. **Acceleration** is the increased rate of change in an object's velocity. **Deceleration** is the decreased rate of change in an object's velocity. In other words, acceleration and deceleration are measures of the change in velocity of an object over a certain period of time. The acceleration of an object is calculated by subtracting the initial velocity from the final velocity and dividing that number by the time over which the change occurred. The units used to measure acceleration are a distance covered in an amount of time multiplied by time.

Suppose a car moves westward at 30 miles per hour. What is its velocity? The velocity of the car is 30 miles per hour to the west. Now suppose the car increases its velocity to 40 miles per hour, in one minute. The acceleration of the car is equal to 40 miles per hour minus 30 miles per hour divided by one minute. The acceleration, then, is 10 miles an hour in one minute toward the west.

Isaac Newton, a famous seventeenth century scientist, was one of the first people to study and understand motion. He developed three scientific laws to explain motion. Newton's **first law of motion** states that an object moving at a constant velocity will continue at that velocity unless acted upon by an outside force. The law also states that an object at rest will tend to remain at rest unless acted upon by an outside force.

Newton's first law is sometimes called the law of inertia. **Inertia** is a property of an object that resists any change in velocity. In order to change the velocity of an object, inertia must be overcome. If you have ever tried to push a stalled car with an automatic transmission, you probably found that it takes a great amount of force to get the car moving. Once the car is in motion, however, the effort to keep it in motion is less than the initial effort. To stop the car again, however, requires a large effort; inertia is acting to keep the car moving. The amount of mass an object has is a measure of its inertia. **Mass** is the amount of matter that makes up an object.

What happens if an outside force acts upon an object? Newton's **second law of motion** states that the acceleration of an object increases as the amount of the force applied on the object increases. The force applied is equal to the object's mass multiplied by the acceleration. The greater the mass of an object, the slower the acceleration. The greater the force applied, the greater the acceleration.

Newton's **third law of motion** states that forces always come in pairs. Therefore, for every action, there is an opposite and equal reaction. You probably didn't realize that if you stand on a carpeted floor and push against a wall, the wall is pushing back against you with equal force. That is why neither you nor the wall moves.

You may be aware of some of the forces that affect your motion. You know, for example, that it is easier to slide on ice than it is to slide across a carpeted floor. **Friction** is a force that opposes or counteracts the motion between two surfaces that are in contact. Which surface provides more friction—the ice or the carpet?

Why does an object fall to the ground when it is dropped? The force of **gravity** pulls objects toward Earth. Gravity exists among all objects. The greater the mass of an object, the greater the force of gravity it exerts. The force of gravity also depends on the distance between two objects. The farther two objects are away from one another, the less the gravitational force is between them. The force of gravity that Earth exerts on an object at its surface is called the object's **weight.** ■

Lesson Review

In the space provided, write the word or words that best complete the statement.

1. ____________________ is a change in position.
2. The rate of change of position is called ____________________.
3. A fielder catching a fly ball is an example of Newton's ____________________ law of motion.
4. ____________________ is a property of an object that resists any change in velocity.
5. The amount of matter that makes up an object is the object's ____________________.
6. According to Newton's second law of motion, pulling a sled with one rider requires ____________________ force than pulling a sled with three passengers.
7. Newton's third law of motion states that forces always come in ____________________.
8. A carpeted surface provides ____________________ friction than a sheet of ice.
9. ● A runner runs west at a speed of two miles an hour on a straight road. She turns left and continues at two miles an hour. The runner's ____________________ has changed.
10. ● As the mass of an object increases, so does its weight. When you diet, you lose mass. Therefore, your weight ____________________.

Lesson 3

Machines

What do a car engine, a hammer, a screw, a doorknob, and a printing press have in common? All are machines. A **machine** is a device that does work by changing one form of energy into another form of energy in order to create force. To do work, a machine changes the speed, the amount, or the direction of a force in order to produce motion.

There are many kinds of machines. Some are very complex, such as a printing press. Crowbars and hammers, on the other hand, are simple machines. Scientists define a simple machine as a machine that is made of only one part. There are six simple machines: the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw.

A **lever** is a simple machine consisting of a bar or rod that turns about a supporting point called a **fulcrum.** Look at the illustration. The man is using a lever made of a wooden pole and a log to move the rock. Notice that one end of the pole is under the rock. The log is the fulcrum. By applying a downward force on the pole, the man can move the rock. If he moved the fulcrum closer to the rock, would it be easier or harder for him to move it?

The weight of an object moved by a machine is its **resistance**. The force used to move the object is the **effort.** In a lever, the distance from the resistance to the fulcrum is called the resistance arm. The distance from the fulcrum to the effort is the effort arm. The resistance multiplied by the resistance arm is always equal to the effort times the effort arm. The work put out by a machine never exceeds the amount of work put into the machine.

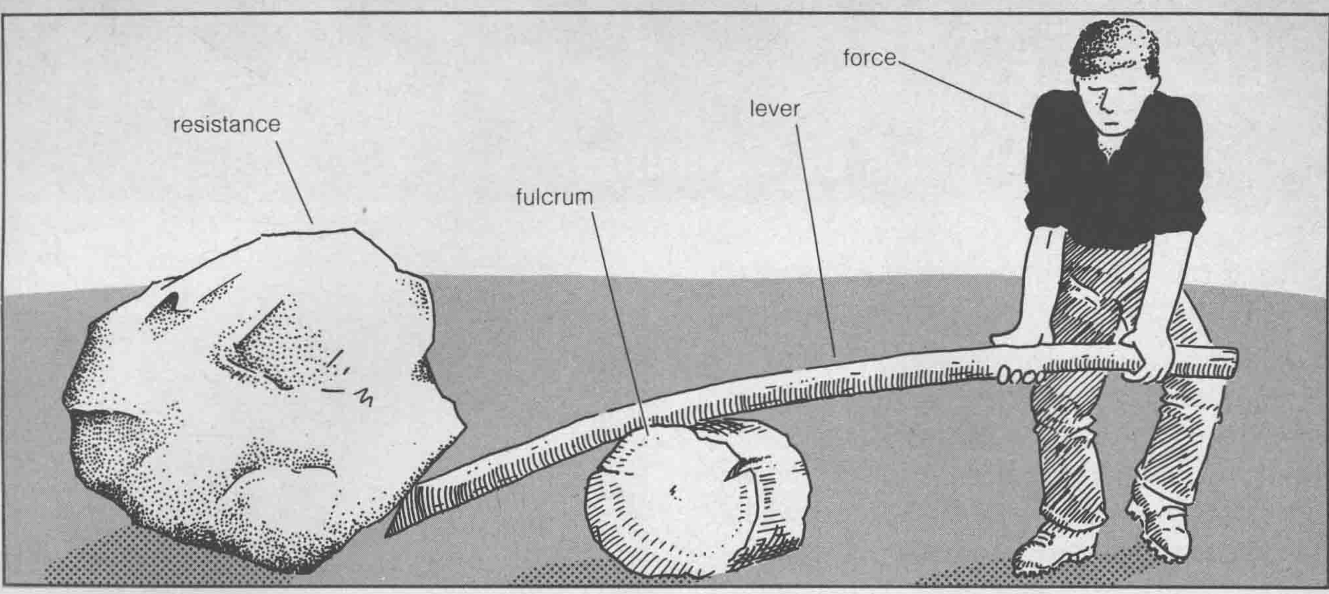
Look again at the illustration. Suppose the rock weighs 75 pounds. The length of the pole is five feet, and the log is two feet from the rock. What amount of force is needed to move the rock? The resistance, 75 pounds, multiplied by its resistance arm, two feet, equals 150 foot-pounds. The effort times the effort arm, three feet, also must equal 150 foot-pounds. Therefore, the minimum effort needed to move the rock is 150 foot-pounds divided by three feet, or 50 pounds. If the fulcrum is placed one foot from the rock, would the needed effort be more or less than 50 pounds?

Construction tools, such as power shovels, cranes, and other loading equipment, use levers to do work. Some of these tools use a special form of a lever called a wheel and axle. A **wheel and axle** is a simple machine that consists of a large wheel that is attached to a smaller wheel or rod called an axle. You have seen a wheel and axle at work when using a doorknob or a pencil sharpener.

A **pulley** is a simple machine in which a rope or cable is strung over a grooved wheel. A pulley changes the direction of the effort. A **block and tackle** is a combination of two or more pulleys which can be used to lift heavy equipment. Construction workers and window washers often use pulleys to raise and lower themselves along the sides of buildings.

An **inclined plane** is simply a slanted surface. Inclined planes are often used by people moving furniture or other heavy objects. It is nearly impossible for a person to lift a 300-pound object from the ground into the back of a truck. But if a plank is placed from the truck to the ground, it takes much less effort to get the object into the truck.

A wedge is a special kind of inclined plane. A **wedge** is an inclined plane that has either one or two slanted edges. Wedges include the sharp ends of knives and most other cutting tools, axes, plows, and chisels.



A lever is a machine that may be used to change the amount and direction of force needed to do work.

A **screw** is really an inclined plane wrapped around a shaft or cylinder. If you look at a screw from the side, you will notice that its threads spiral upward. There are many different kinds of screws. Wood screws are used in pieces of furniture. Metal screws are found in many machine parts. Large screws called jack screws can lift cars and houses.

Many of the machines you use are combinations of simple machines. A bicycle is a combination of levers and wheels and axles. A machine made of two or more simple machines is called a **compound machine.** ■

Lesson Review

In the space before each number, write the letter of the word or group of words in Column 2 that matches the description in Column 1.

	Column 1	Column 2
______	1. the supporting point of a lever	a. compound machine
______	2. the weight of an object being moved by a machine	b. effort
______	3. the force used to move an object	c. fulcrum
______	4. a simple machine made of a rope and a wheel	d. inclined plane
______	5. an inclined plane with one or two slanted edges	e. lever
______	6. an inclined plane wrapped around a shaft	f. pulley
______	7. a combination of two or more simple machines	g. resistance
______	8. a compound machine made of a lever and wedge	h. screw
• ______	9. a ramp is this type of simple machine	i. shovel
• ______	10. a hand-held bottle opener is this type of simple machine	j. wedge

Lesson 4

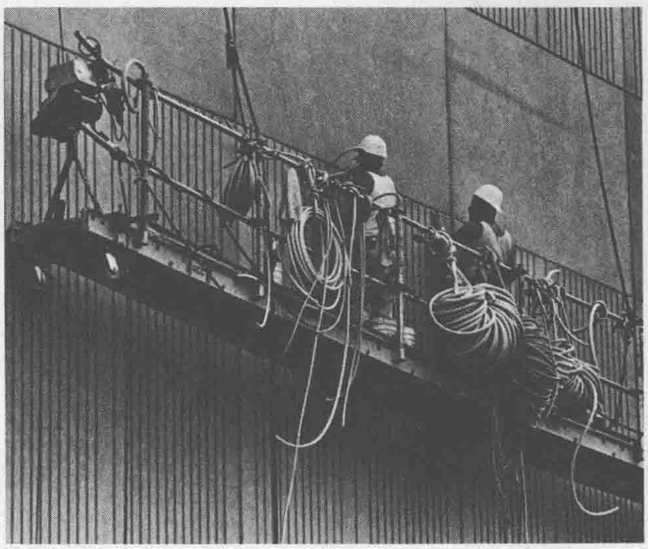
The Usefulness of Machines

In order to lift a box that weighs 150 pounds, the average person would have to exert a considerable amount of force to overcome inertia and gravity. Machines reduce the amount of energy that is needed to move objects that are quite heavy. By using a wheel and axle or an inclined plane, the 150-pound box can be lifted with as little as 20 percent of the force that would be needed if the box were lifted by hand.

The usefulness of a machine can be described using three terms: mechanical advantage, efficiency, and power. **Mechanical advantage** is the number of times that the effort is multiplied by using the machine to move the resistance. Recall that the effort is the force that is needed to move an object. The weight of an object is its resistance. If a machine uses four pounds of force to move a 20-pound object, what is the machine's mechanical advantage? By dividing the weight of the object by the amount of force needed to move it, the mechanical advantage is found. The mechanical advantage of the machine is five.

What is the relationship between mechanical advantage and energy? The greater the mechanical advantage of a machine, the less energy that is needed to do a job. A block and tackle has a high mechanical advantage. Would these machines be better for lifting lightweight objects or very heavy objects?

Recall that the law of conservation of energy states that energy can neither be created nor destroyed. As a result, no more energy can be gotten out of a machine than the amount of energy that is put into it. The work that a machine does is the machine's **output.** The output is the amount of energy released by the machine when doing a job. The energy that is put or designed into a machine is the machine's **input.** The machine's input is the amount of energy that a machine has available to release in order to get the job done. The output of a machine is always less than its input because of the action of gravity, inertia, and friction.



Simple machines, such as pulleys, have high efficiencies.

The **efficiency** of a machine is the relationship between the force it puts out and the force that it could put out if it did not have to overcome the forces of gravity, inertia, and friction that are acting upon it. A machine's efficiency is expressed as a percentage, with 100 percent being perfect efficiency. Of course, no machine has 100 percent efficiency due to the energy lost in overcoming friction.

A simple machine, such as a crowbar, approaches 100 percent efficiency because it must overcome very little friction. Many compound machines, on the other hand, have low efficiencies. Most automobile engines, for example, are only about 25 percent efficient. About 75 percent of the chemical energy released by gasoline is used to overcome the friction that is developed by the many moving parts of the engine. To improve the efficiency of many machines, smoother surfaces, ball bearings, and a variety of lubricants are used to help reduce friction. Reducing friction makes the machines more efficient and cheaper to operate.

Power is the rate at which a machine does work. In other words, power is the amount of work done in a certain amount of time. The greater the power of a machine, the faster it completes a job. It takes more power to do work in five minutes than it does to do the same work in ten minutes.

The power of most mechanical machines is measured in foot-pounds per second. Recall that one foot-pound is the amount of work done when moving a one-pound object a distance of one foot. Horsepower was originally used to represent the amount of power that an average horse could deliver. The term is now used to measure the power delivered by many engines and motors. One horsepower equals 550 foot-pounds of work completed in one second. ■

Lesson Review

In the space provided, write the word or words that best complete the statement.

1. To lift a box, a machine has to overcome the forces of ____________________ and ____________________.
2. ______________________________ is the number of times the effort is multiplied in moving the resistance.
3. The greater the mechanical advantage of a machine, the ____________________ energy needed to do the job.
4. The ____________________ of a machine is the work that the machine does.
5. ______________________________ is the relationship between a machine's input and output.
6. Compound machines have ____________________ efficiencies.
7. Reducing ____________________ makes machines more efficient and therefore cheaper to operate.
8. The rate at which a machine does a job is the ____________________ of the machine.
9. ● A machine that puts out five pounds of force to move a 30-pound object has a mechanical advantage of ____________________.
10. ● A machine such as a lever has a very ____________________ mechanical advantage.

Lesson 5

Energy Transfer in an Automobile

An automobile is a compound machine. Recall that a compound machine is a machine made of two or more simple machines. An automobile is made of many simple machines. Most people get into a car, put the key into the ignition, start it up, and drive away. Many of them don't realize that energy is being transferred many times as the car does work. How does your car work?

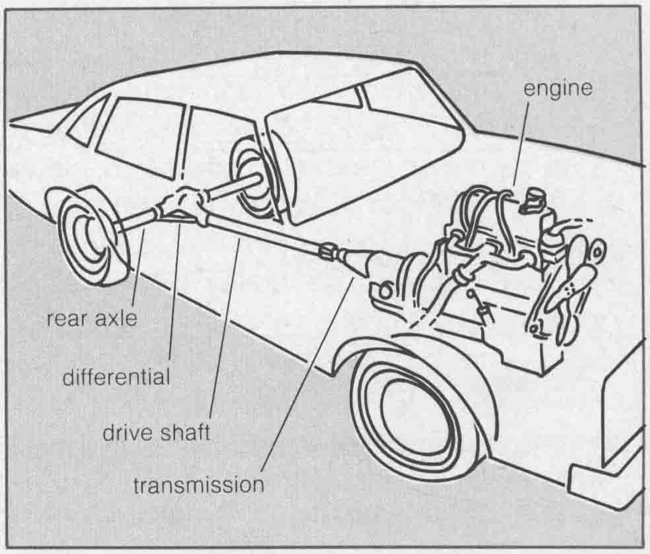
Recall that chemical energy is stored in gasoline. In order for the car's engine to do work, this chemical energy must be released and transferred to the various other parts of the car so that the car will do what it was designed to do. A crankshaft, which is really the simple machine called a wheel and axle, is set into motion when energy from the burning fuel causes the shaft to turn. This shaft is connected to the engine's pistons. As the shaft turns, the pistons move up and down. The revolving shaft also transfers energy to a flywheel, which is attached to the rear of the engine. The flywheel transfers energy to the car's transmission.

An automobile's transmission is a system of gears. **Gears** are wheels with teeth, or notches, around their outer edges. The notches of two gears fit together to keep the gears from slipping as they turn, and allow the gears to work smoothly as they transfer energy.

The transmission in most cars consists of four forward gears and one reverse gear. When you drive a car with a standard transmission, you are able to select the proper gear needed to produce the speed that you need in a particular situation. Low, or first, gear provides the maximum force and slow speed needed to move the car or to drive up steep hills. Second gear produces less force and more speed than first gear. Third and fourth gears are used for faster driving. Do these gears provide more or less force than second gear? Why?

Gears transfer energy to the car's drive shaft. The **drive shaft** is a rod that runs from the transmission to the car's rear axle. At the rear axle, the rotating drive shaft transfers energy to another set of gears called the **differential,** which is mounted to the center of the rear axle.

The differential is made of several simple machines. Recall that any machine changes the speed, the amount of force, or the direction of force in order to do work. When your car makes a right turn, the left rear wheel travels farther and faster than the right rear wheel. It is the differential that allows the two rear wheels to turn at different rates. Look at the illustration. What other purpose does the differential serve? The differential also changes the direction of the force from the drive shaft to the rear wheels and axle.



Energy is transferred from a car's engine down the drive shaft to the rear wheels.

A gear at the end of the drive shaft meshes with gears on each end of the rear axle. The rear axle is connected to each of the back wheels of the car. This final transfer of energy allows the wheels of the car to turn. If the car is a front-wheel drive model, energy is channeled in a similar way to the car's front wheels, rather than to the rear wheels.

Recall that friction is a force that must be overcome in order for machines to do work. Recall also that most automobile engines are only about 25 percent efficient. To improve your car's efficiency, friction must be reduced. To combat friction, lubrication is essential to the maintenance of any compound machine, including your car. Oil and grease are two lubricants used to reduce friction in automobiles. Oil in the engine's crankcase lubricates the pistons and the drive shaft. Fluid in the transmission lubricates its gears. Grease is used to reduce friction produced by the meshing gears in the differential. Belts and other moving parts also require special lubrication in order to operate smoothly. ■

Lesson Review

In the space before each number, write the letter of the word or group of words in Column 2 that matches the description in Column 1.

	Column 1	Column 2
______	1. shaft that is set into motion from the burning of gasoline	a. ball bearings
______	2. car part that transfers energy to the car's transmission	b. crankshaft
______	3. wheels with teeth or notches around their outer edges	c. differential
______	4. shaft that runs from the transmission to the rear axle	d. drive shaft
______	5. allows the rear wheels of a car to travel at different speeds	e. flywheel
______	6. rod connected to both rear wheels	f. friction
______	7. force that must be overcome in order for a machine to do work	g. gasoline
______	8. reduces friction in the drive shaft and in the engine's pistons	h. gears
• ______	9. reduces friction in automobile wheels	i. oil
• ______	10. energy source for an automobile engine	j. rear axle