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SCIENCE

STUDENT BOOK

6th Grade | Unit 7

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SCIENCE 607

Motion and its Measurement

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Motion and its Measurement

Introduction

Motion is the moving of an object or material from one place to another. Motion occurs when anything changes its location in space. Everything in the universe is in motion. As you read these words, you are in motion. You are moving with the earth as it rotates about its axis. You are also moving with the earth as it revolves about the sun. In addition, you are moving as the earth and the sun rotate in the Milky Way Galaxy. Even the Milky Way Galaxy is in motion through space. You are in constant motion!

But, motion occurs on a small scale as well. Atoms and molecules that make up all matter are also moving. Even the electrons inside the atoms are moving. They move around the nucleus in different shells. The protons and neutrons within the nucleus are also in motion.

The earth moves on its axis. This movement results in day and night. The tilt of the earth and its movement around the sun are what give us the seasons. All things in the universe move. The earth, planets, and stars continually move. God has promised that these forms of motion shall not stop. In Genesis 8:22b, we read, "... summer and winter, and day and night shall not cease."

In this LIFEPAC®, you will study motion and its measurement. You will also study some of the machines that man uses to change motion.

Objectives

Read these objectives. The objectives tell what you should be able to do when you have completed this LIFEPAC. When you have completed this LIFEPAC, you should be able to do the following:

1. Define force and explain different types of forces, including gravity, force of water, and muscular force.
2. Tell what a scientist means by work.
3. Compute amounts of work in foot-pounds or in kilogram-meters.
4. Explain that all things in the universe are in motion, including all matter, atoms, planets, and stars.
5. Summarize Newton's Laws of Motion and Law of Gravitation.
6. Define power in the scientific sense.
7. Compute power (rate of doing work).
8. Define a machine and describe how people use machines to change motion.
9. Tell the meaning of the work principle.
10. Define and distinguish among the terms *friction, inertia,* and *gravity.*

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

1. MOTION, FORCE, AND WORK

Motion occurs when an object moves through space. Motion is a relative term because it is always relative to a reference. An object may be in motion when compared to another object but **stationary** compared to a third object. For example, as you travel along in a car, you are in motion compared to a sign on the highway, but you are stationary compared to the person sitting next to you in the car.

Force is any cause that changes the motion or shape of an object. In regards to motion, force can be defined as a push or a pull. When you want to move an object, you use force. When enough force is applied, the object moves and is in motion. Other forces acting on the moving object can change its motion. Gravity pulls things toward the center of the earth. To lift an object, you must exert force. The force you exert must be greater than the force of gravity. Because of the pull of gravity, more force is required to lift an object than to push it along a smooth surface.

In this section of the LIFEPAC, you will study how man uses force to do work and how work is measured.

Section Objectives

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

1. Define force and explain different types of forces, including gravity, force of water, and muscular force.
2. Tell what a scientist means by work.
3. Compute amounts of work in foot-pounds or in kilogram-meters.
4. Explain that all things in the universe are in motion, including all matter, atoms, planets, and stars.

Vocabulary

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

foot-pound (fūt pound). A unit for measuring work which is equal to the amount of energy required to move one pound one foot. It is the unit of measure used to compute horsepower.

force (fôrs). A push or pull action on an object.

gravity (grav ə tē). The force that pulls things toward the center of the earth and which accounts for the fact that all matter is attracted to other bits of matter in the universe. For example, you are pulled toward the center of the earth, the earth is attracted to the sun, and so on.

kilogram-meter (kil ə gram mē tər). One of the units for measuring work in the metric system.

stationary (stā shə ner ē). Fixed in the same place or condition.

work (wėrk). The product of force moving through a distance.

Note: *All vocabulary words in this LIFEPAC appear in* **boldface** *print the first time they are used. If you are unsure of the meaning when you are reading, study the definitions given.*

Pronunciation Key: h**a**t, **ā**ge, c**ã**re, f**ä**r; l**e**t, **ē**qual, t**ė**rm; **i**t, **ī**ce; h**o**t, **ō**pen, **ô**rder; **oi**l; **ou**t; c**u**p, p**u̇**t, r**ü**le; **ch**ild; lo**ng**; **th**in; /ŦH/ for **th**en; /zh/ for mea**s**ure; /u/ or /ə/ represents /a/ in **a**bout, /e/ in tak**e**n, /i/ in penc**i**l, /o/ in lem**o**n, and /u/ in circ**u**s.

WORK IS ACCOMPLISHED BY FORCE

People use **force** to do **work**. Scientists define work in a special way. To do what they consider work, you must do more than just exert a force. Perhaps you think of "work" as a job or a means of earning money. Scientists do not think of it in this way. According to them, work is done only when a force moves an object through some distance.

For example, if you try to push a piano and are unable to move it, you have not done work. In order for work to be accomplished, the piano must be moved through space. To accomplish work, you must apply enough muscular work for the piano to move. Even though you may have spent a lot of energy trying to move the piano, if it does not move, you have not done any work. If your muscular force is sufficient to move the piano, you do work.

Suppose someone nailed a box to the floor, and you tried to move it. You exerted a force, but the box did not move. Therefore, you did no work. You do work only when the force you exert moves an object through a distance.

There are many examples of work that you do every day. When you walk, you work, because your body moves through a distance. You exert a muscular force on the weight of your body, causing it to move, and you do work.

Many kinds of forces exist. One kind that we have just discussed is muscular force. Another kind of force common on earth is the force of **gravity**. You learned in a previous LIFEPAC that the force of gravity acting on the mass of an object is called its weight. The force of gravity

| The force of gravity pulls down on our bodies

pulls down on our bodies to keep us on the earth.

Another type of force in nature is the force of *wind*. Windmills move and pump water through the force of wind acting on the blades of the windmill. Another kind of natural force is that of water. When the force of falling water moves the blades of a turbine at a hydroelectric plant, electricity is generated. The force of water can also move your canoe or raft as you float down a river. The force of steam acting on a piston can operate an engine. Old steam locomotives, now mostly the fancy of railroad hobbyists, are good examples of how the force of steam can do work. All of these kinds of forces—and more—are used by people to do work.

| The force of wind turns windmill blades

Complete the following activities.

1.1 What is motion? _____

_____

1.2 What is force? _____

_____

1.3 What is work? _____

_____

1.4 Name at least three kinds of natural forces and give an example of each.

	Kind of Force	**Example**
a.	_____	_____
b.	_____	_____
c.	_____	_____

MEASUREMENT OF WORK

Work is defined as the amount of force on an object times the distance the object moves. It is expressed by the following mathematical formula:

WORK = FORCE x DISTANCE

Two factors determine the amount of work that is done on an object. One factor is the amount of force applied to the object. The other factor is the distance the object moves. To measure work, you need to know how much force is applied and the distance an object moves. The actual value of the work measured depends upon the system of measurement used. Both the English system and the metric system are used in the United States. For most scientific measurement, the metric system is used.

Foot-pound. The unit for measuring work in the English system (or *customary system*) of measurements is the *foot-pound*. If a force of 1 pound moves an object 1 foot, then the amount of work accomplished is 1 foot-pound of work. Note in the English system that an object weighing 1 pound would require a force of 1 pound to lift it. Therefore, to lift a weight of 1 pound a distance of 10 feet from the ground would require 1 pound x 10 feet = 10 foot-pounds of work. To lift a two-pound object a distance of 10 feet would require 2 x 10 = 20 foot-pounds of work.

Joule or newton-meter. In the metric system, the unit of measuring work is the *joule* or the *newton-meter*. It is the unit of force equivalent to the force that produces an acceleration of one meter per second on a mass of one kilogram. Sometimes, it is also convenient to measure work in the metric system in units of *kilogram-meter*. For example, if an object weighing 1 kilogram is lifted a distance of 1 meter, the amount of work accomplished is 1 kilogram x 1 meter = 1 **kilogram-meter**.

Work rate and calculations. Work is measured by multiplying the force (weight) applied to an object by the distance the object is moved. It does not make any difference whether the work is done quickly or slowly. If the same weight is lifted through the same space in 3 minutes or 3 hours, the same amount of work is done. The rate, or speed, of doing work will be discussed in the next section of this LIFEPAC.

If you have 50 boxes to be moved from a truck to a house, the same amount of work is required whether five men move the boxes or one man moves the boxes. The total amount of work is the same. Only the rate or speed of doing the work would be different. Work is always computed by multiplying the force (weight) times the distance moved whether the work is done quickly or slowly.

When a 20-pound object is lifted 100 feet, the same amount of work is done as when a 100-pound object is lifted 20 feet. In both examples, there are 2,000 foot-pounds of work done. Also, the same amount of work is done whether one person supplies the force to lift the weight or three people lift it.

Match the following items.

1.5 _____ work

1.6 _____ steam

1.7 _____ foot-pound

1.8 _____ kilogram-meter

1.9 _____ force of gravity

1.10 _____ muscular force

1.11 _____ water force

1.12 _____ force of wind

a. force used to generate electricity through turbines

b. metric measurement of work

c. English system measurement of work

d. force used to turn windmill

e. kind of force that pulls things toward the center of the earth

f. kind of force used to operate some engines

g. amount of force times the distance it moves an object

h. force used when walking

Complete the chart.

1.13 Using the formula for work, calculate the amount of work done for the following examples.

	Force	**x**	**Distance**	**=**	**Work Performed**
a.	10 pounds		10 feet		_____
b.	10 pounds		20 feet		_____
c.	37 pounds		10 feet		_____
d.	29 pounds		100 feet		_____
e.	2 newtons		1 meter		_____
f.	30 kilograms		2 meters		_____

TEACHER CHECK _____ initials _____ date

Try this experiment to learn more about forces of lifting and pulling.

Overview. You will lift and pull objects, noting any differences in the forces required to do the work of lifting and pulling.

These supplies are needed:

- 1 spring scale with a hook (The type of scale used for weighing fish is most suitable. See illustration in step 1 below.)
- 1 heavy box filled with something to make it weigh about 3 pounds (The box may be filled with wood, rocks, books, etc.) (You can also weigh the objects in a plastic zip top bag. If your scale has a smaller capacity than 3 pounds, then use less weight.)
- heavy cord twine or rope (Not needed if you use a plastic bag. Just make a small hole in the top of the bag and hook it to the scale.)

Follow these directions and complete the activities. Place a check mark in the box as you complete each step.

☐ 1. Tie a heavy cord around the box indicated and hook the scale on the cord. Lift the box upward from the surface for a distance of one foot with the spring scale.

1.14 Record the weight showing on the scales as you lifted the box.

_____

1.15 How many foot-pounds of work were done? _____

___

Hint: Force (weight from scale reading in 1.14) x distance (1 foot) = work done

☐ 2. Place the box on a smooth surface (like a desk or table). Pull the box across the surface for a distance of one foot with the spring scale.

1.16 Record the weight showing on the scales as you pulled the box. _____

1.17 How many foot-pounds of work were done? _____

Hint: Force (weight from scale reading in 1.16) x distance (1 foot) = work done

1.18 What is the difference (in foot-pounds) between the amount of work required to lift the box and to pull the box? _____

Experiment 607.A Forces of Lifting and Pulling

(continued on next page)

1.19 Why is there a difference between lifting an object and pulling it across a smooth surface? Hint: What force are you working against when you lift an object?

_____

_____

_____

_____

1.20 Find another object to lift and pull with the spring scale. Write the difference in foot-pounds between lifting and pulling.

a. lifting _____ b. pulling _____ c. difference _____

d. Write your conclusions from this experiment in your own words.

_____

_____

_____

TEACHER CHECK _____ initials _____ date

Experiment 607.A Forces of Lifting and Pulling

Complete the following activity.

1.21 Unscramble these words. When you have unscrambled each word, study its definition by referring to the vocabulary list. Place a check mark in each box when you are sure you have learned each definition.

a. C R O F E _____

b. R O W K _____

c. T A R V G I Y _____

d. T O F O - U N D O P _____

e. M O G L I K A R - T R E E M _____

TEACHER CHECK _____ initials _____ date

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

Match the following items (each answer, 2 points).

1.01 _____ occurs when anything changes its location in space

1.02 _____ a push or pull action

1.03 _____ the force that pulls things toward the center of the earth

1.04 _____ the metric measurement of work

1.05 _____ force x distance

1.06 _____ force used to walk up the steps

1.07 _____ force used to move a windmill

1.08 _____ some engines operate on this force

1.09 _____ force used to generate some electricity

1.010 _____ English (customary) measurement of work

a. work
b. steam
c. water
d. gravity
e. force
f. stationary
g. motion
h. muscular
i. foot-pound
j. joule
k. wind

Answer true or false (each answer, 2 points).

1.011 _____ Our bodies are in constant motion even when they appear to be at complete rest.

1.012 _____ All matter, except hard objects like steel and iron, are in motion.

1.013 _____ All things in the universe are in motion.

1.014 _____ More force is required to pull an object than to lift it.

1.015 _____ Scientists define work as force moving an object through a distance.

1.016 _____ An object may be in motion when compared to another object but stationary compared to a third object.

1.017 _____ A moving body will continue in motion in spite of forces acting upon it.

1.018 _____ The same amount of work is done when 20 pounds are lifted 100 feet as when 100 pounds are lifted 20 feet.

1.019 _____ If you have 10 boxes to be lifted to a platform, the same amount of work is done whether 1 person or 5 people move the boxes.

1.020 _____ Gravity pulls things toward the center of the earth.

Compute the amount of work performed (each answer, 3 points).

	Force	Distance	Work Performed
1.021	10 pounds	10 feet	_____
1.022	10 pounds	20 feet	_____
1.023	37 pounds	10 feet	_____
1.024	29 pounds	100 feet	_____
1.025	2 newtons	1 meter	_____
1.026	30 kilograms	2 meters	_____

Fill in the correct answers (each answer, 3 points).

1.027 The force you exert to lift an object must be greater than the force of _____ _____ .

1.028 Force is any cause that changes the _____ or shape of an object.

1.029 If your muscular force is sufficient and you move a piano, you do _____ .

1.030 If the same weight is lifted through the same space in 3 minutes or 3 hours, the _____ amount of work is done.

Answer the following questions (each answer, 10 points).

1.031 Explain how all things, even your body when it rests, are in constant motion.

_____

_____

_____

_____

1.032 How much work is done if a 200-pound man pushes on a large rock for 2 hours but does not move it? Explain your answer. _____

_____

_____

_____

1.033 What are 3 kinds of forces found naturally occurring in nature and what is an example of each? _____

_____

_____

_____

_____

_____

_____

80/100 **SCORE**_____ **TEACHER**_____ _____
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