LIFEPAC®

SCIENCE

STUDENT BOOK

12th Grade | Unit 1

Alpha Omega PUBLICATIONS

SCIENCE 1201

KINEMATICS

LIFEPAC Test is located in the center of the booklet. Please remove before starting the unit.

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Alpha Omega PUBLICATIONS

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Kinematics

Introduction

You are about to begin a study of physics, the fundamental science of the natural world. This course is your opportunity to study laws that God established when he created heaven and earth. We will start with kinematics, which is a branch of mechanics dealing with the mathematical methods of describing motion. Motion is defined as a continuous change of position.

Objectives

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

1. Identify the fundamental units of physics.
2. Use scientific notation in calculations.
3. Use prefixes of the metric system.
4. Identify and explain scalar quantities.
5. Calculate vectors using vector arithmetic.
6. Distinguish between distance and displacement.
7. Calculate problems involving distance and displacement.
8. Calculate problems involving area, volume, and density.
9. Distinguish between speed (a scalar) and velocity.
10. Calculate problems involving speed and velocity.
11. Distinguish between average speed and average velocity.
12. Calculate problems involving average speed and average velocity.
13. Identify the circumstances that produce acceleration.
14. Calculate problems involving acceleration.
15. Describe a field.
16. Define a model.

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

1. UNITS, SCALARS, AND VECTORS

Prior to studying motion, you will need to become acquainted with units used in this course—the metric system or SI units—and the concept of **scalar** and **vector** quantities.

Section Objectives

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

1. Identify the fundamental units of physics.
2. Use scientific notation in calculations.
3. Use prefixes of the metric system.
4. Identify and explain scalar qualities.
5. Calculate vectors using vector arithmetic.

Vocabulary

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

component	**inertia**	**kinematics**	**length**	**mass**	**prefix**
resultant	**scalar**	**scientific notation**	**time**	**vector**	

Note: *All vocabulary words in this LIFEPAC 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.*

UNITS

You will use primarily the *MKS* (meter-kilogram-second) *system* or the *cgs* (centimeter-gram-second) *system* in this course. Let's review these systems.

Time. Time, according to Sir Isaac Newton, is that which flows onward uniformly. It is a fundamental, indefinable unit in physics. A day is a logical portion of time. However, the reason for dividing the day into twenty-four portions called *hours* is obscure. The hour is divided into sixty equal portions called *minutes*, and the minute into sixty equal portions called *seconds*.

Length. Length is the measurement describing the distance from one location to another. Historically, every nation had its own unit of length. We will use the *meter* (a little longer than a yard) and the *centimeter* (a little less than half an inch) as units of length. Length, too, is a fundamental, indefinable unit in physics.

Mass. The third fundamental unit in physics is **mass**, which can be defined as the quantity of matter that a body possesses. We will use the *kilogram* (approximately the mass of an object weighing two pounds at sea level) or the *gram*, which is one-thousandth of a kilogram. Please note that the kilogram is *not equal* to 2.2 pounds, because a pound is a unit of force and not a unit of mass. However, we can define the kilogram as equivalent to the mass that weighs 2.2 pounds at sea level. This distinction between mass and weight is important and is quite often misstated.

Another means of defining *mass* is to use the term **inertia**, which is the apparent resistance of matter to a change in motion.

All other measurements (with the exception of temperature and electric current) are defined in terms of time, length, and mass.

You should understand these concepts before continuing. Figure 1 lists the fundamental metric units and their multiples and subdivisions. Notice the abbreviations given.

Length	Time	Mass
1 meter (m) = the standard unit = 39.37 inches = 3.28 feet	1 second (s) = the standard unit	1 kilogram (kg) = the standard unit
1 centimeter (cm) = 0.01 meter	1 minute (min) = 60 seconds	1 gram (g) = 0.001 kilogram
1 millimeter (mm) = 0.1 centimeter = 0.001 meter	1 hour (hr) = 60 minutes = 3600 seconds	1 milligram (mg) = 0.001 gram = 0.000001 kg
1 kilometer (km) = 1000 meters = 0.621 mile	1 day = 24 hours = 86,400 seconds	(1 kilogram corresponds to 2.21 pounds in the sense that the weight of 1 kilogram is 2.21 pounds at sea level.)

| Figure 1: Metric Units

Complete these sentences.

1.1 That which flows onward uniformly, of which a day is a logical portion, is called ______________ .

1.2 The distance from one place to another is ________________ .

1.3 The term used to describe the quantity of matter that a body possesses is _________________ .

1.4 The branch of mechanics dealing with the mathematical methods of describing motion is called ___________________________ .

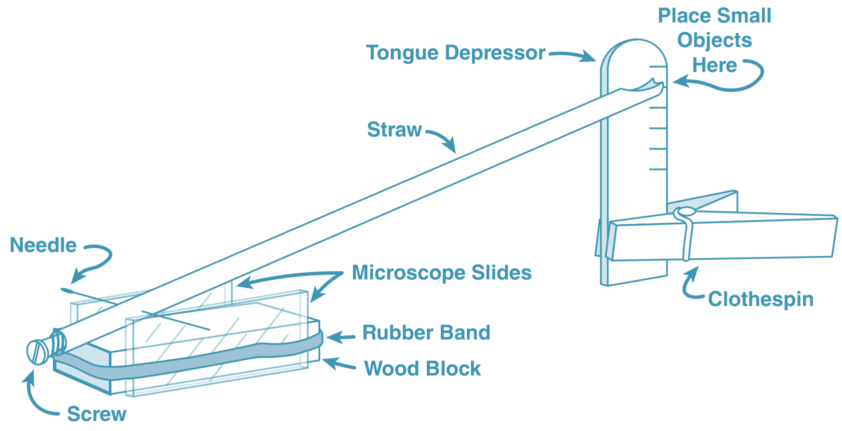
Measure Small Objects Experiment

Try this investigation. Anyone can measure most masses using equal-arm or triple-beam balances, but what about measuring very small objects? Expensive equipment is not necessary.

These supplies are needed:

- 1 screw
- 1 paper straw
- 2 microscope slides
- 1 needle
- 1 ruler
- 1 razor blade or scissors
- 1 small wood block
- 1 tongue depressor
- 1 clothespin
- 100 sheets paper
- balance or electronic kitchen scale

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



| Figure 2: Soda Straw Balance

- ☐ 1. Place the screw about half its length into the straw and determine where the balance is.
- ☐ 2. Balance the straw containing the screw on your finger.
- ☐ 3. Push the needle through the straw at the balance. The needle should be slightly above the centerline of the straw.
- ☐ 4. Cut open the other end so that a lip is formed to hold objects.
- ☐ 5. Balance the straw on the glass slides by turning the screw.
- ☐ 6. Hold the tongue depressor upright with the clothespin.
  You have now constructed a “soda straw” balance. Your “soda straw” balance must be calibrated.
- ☐ 7. Count out 100 sheets of paper (all the same type), and measure the mass in grams on any available scale. Record this answer in 1.5.
- ☐ 8. Measure the length and width of one sheet of paper in centimeters (cm) and calculate the number of square centimeters (cm^2) in one sheet. Record this answer in 1.7.

1.5 What is the mass of 100 sheets of paper? ______________________________

1.6 What is the mass of one sheet of paper? ______________________________

(Continued on next page)

1.7 How many square centimeters are in the one sheet of paper? ______________________

1.8 What is the mass of 1 cm^2 (square centimeter) of paper? ______________________

☐ 9. Cut about ten square centimeter pieces from your paper by using a ruler and razor blade or scissors. Do not mark your paper with a pencil; graphite will contribute mass. Be careful in handling your paper; perspiration will also contribute undesirable mass.

☐ 10. Place a 1 cm^2 piece of paper on the lip of your scale; and, if necessary, cut your 1 cm^2 piece into smaller pieces so that each piece will move the soda straw no more than one-fifth the length of the marker.

1.9 What size piece of paper will you use? ______________________

1.10 What is the mass of this piece of paper? ______________________

☐ 11. Make several pieces of paper precisely the same size.

☐ 12. Mark the tongue depressor *0* for no paper on the straw, *1* for one piece of paper on the straw, *2* for two pieces, and so on. You have now calibrated your balance.

Now you may find the masses of various objects: hair, grains of salt, etc.

☐ 13. Obtain strands of hair of different shades (blond, brown, and black) and cut them to equal lengths. Place them one at a time on your scale and find their masses.

1.11 Which strand of hair had the most mass? ______________________

CHECK ______________ ______________
Teacher Date

Scientific notation. In physics (and in other sciences) we often deal with very large and very small dimensions. A method has been devised for expressing large and small numbers. This method, called **scientific notation**, expresses numbers as multiples of powers of ten.

First, let us learn to express place values as powers of ten.

$$1000 = 10 \cdot 10 \cdot 10 = 10^3$$
$$100 = 10 \cdot 10 = 10^2$$
$$10 = 10 = 10^1$$
$$1 = 10^0$$
$$0.1 = \frac{1}{10} = 10^{-1}$$
$$0.01 = \frac{1}{100} = \frac{1}{10 \cdot 10} = \frac{1}{10^2} = 10^{-2}$$
$$0.001 = \frac{1}{1000} = \frac{1}{10 \cdot 10 \cdot 10} = \frac{1}{10^3} = 10^{-3}$$

Once this pattern is understood, the following steps should be obvious:

$$2{,}000 = 2 \cdot 1{,}000 = 2 \cdot 10^3$$
$$54{,}300 = 5.43 \cdot 10{,}000 = 5.43 \cdot 10^4$$
$$0.02 = 2 \cdot \frac{1}{100} = 2 \cdot 0.01 = 2 \cdot 10^{-2}$$
$$0.0006 = 6 \cdot \frac{1}{10{,}000} = 6 \cdot 0.0001 = 6 \cdot 10^{-4}$$

Notice that with numbers larger than 1, count the number of places moved to the left and this number becomes a positive exponent.

$$186{,}000 = 1\underbrace{8\,6\,0\,0\,0}_{5\;4\;3\;2\;1} = 1.86 \cdot 10^5$$

For numbers less than one, count the number of decimal places moved to the right. This number becomes the negative exponent.

$$0.0000067 = \underbrace{0\,0\,0\,0\,0\,6}_{1\;2\;3\;4\;5\;6}\,7 = 6.7 \cdot 10^{-6}$$

Notice that in scientific notation the number is usually expressed as shown:

$a.bc \cdot 10^n$,

where a, b, and c are whole numbers, and n may be a positive or negative integer.

When adding or subtracting numbers expressed in scientific notation, the powers of ten must be the same. If they are not the same, then one must be changed in order that they be the same. For example,

$$4.80 \bullet 10^6 + 7.2 \bullet 10^5$$

$$4.80 \bullet 10^6 = 48.0 \bullet 10^5$$
$$+ 7.2 \bullet 10^5$$
$$55.2 \bullet 10^5 = 5.52 \bullet 10^6$$

Notice that the coefficients are added, but the exponents are not.

When multiplying or dividing, follow the rules for multiplying or dividing the coefficient of the notation. If multiplying add the exponents. For example,

$$(6.0 \bullet 10^5)\,(5.0 \bullet 10^3) =$$
$$30 \bullet 10^{5+3} =$$
$$30 \bullet 10^8 =$$
$$3.0 \bullet 10^9$$

$$(6.0 \bullet 10^4)\,(7.0 \bullet 10^{-2}) =$$
$$42 \bullet 10^{4+(-2)} =$$
$$42 \bullet 10^2 =$$
$$4.2 \bullet 10^3$$

If dividing, subtract the exponents. For example,

$$6.0 \bullet 10^5 \div 3.0 \bullet 10^3 =$$
$$^{6.0}/_{3.0} \bullet 10^{5-3} =$$
$$2.0 \bullet 10^2$$

$$6.0 \bullet 10^5 \div 3.0 \bullet 10^{-3} =$$
$$^{6.0}/_{3.0} \bullet 10^{5-(-3)} =$$
$$2.0 \bullet 10^8$$

For a more thorough review of scientific notation, see Science LIFEPAC 1101.

Calculate each answer and record in scientific notation.

1.12 Calculate $8 \bullet 10^{-4}$ divided by $2 \bullet 10^2$.

1.13 Calculate $1.6 \bullet 10^3$ times $3.0 \bullet 10^{-6}$.

1.14 Calculate $9 \bullet 10^{-5}$ divided by $3 \bullet 10^{-9}$.

Prefixes are another means of expressing large or small numbers. For example, if you were referring to 3000 m, you could express it as $3 \bullet 10^3$ m, or as 3 kilometers (3 km) because *kilo* means 1000, or 10^3.

The following list includes prefixes, their power-of-ten equivalents, and abbreviations. An example is given for each prefix. These prefixes should be memorized.

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