LIFEPAC®

SCIENCE

STUDENT BOOK

12th Grade

Alpha Omega PUBLICATIONS

LIFEPAC | aop.com

SCIENCE 1201

KINEMATICS

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

Dynamics

Introduction

Having a foundation of kinematics in physics, you will begin a study of dynamics (from the Greek word "*dynamis*," meaning *power*). In dynamics, we will observe and discuss the causes of motion, what is actually moving, and how the nature of the object affects the motion. You have already studied one very famous scientist, Galileo; now you will encounter two others, Sir Isaac Newton and Johannes Kepler.

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 and explain Newton's first law of motion and second law of motion.
2. Identify and explain force, impulse, and momentum.
3. Solve problems involving Newton's second law of motion.
4. Explain why all objects exert a gravitational force.
5. Explain the difference between gravitational and inertial masses.
6. Calculate the acceleration due to the earth's gravitational field.
7. Solve problems using the equations of motion with acceleration due to the earth's gravity.
8. Explain how different objects' gravitational fields differ.
9. Explain the cause of centripetal acceleration.
10. Calculate problems involving centripetal acceleration and centripetal force.
11. Identify and explain Newton's third law of motion.
12. Apply the conservation of momentum concept in solving problems.
13. Solve problems using vector arithmetic.
14. Identify and explain Kepler's laws of planetary motion.
15. Solve problems using Kepler's laws of motion.

1. ENERGY TRANSFER

Energy is transferred in only two ways, by particle motion and by **wave** motion. A moving particle has kinetic energy proportional to its mass and **velocity**. The energy of a wave is not so simple to assign. Under certain conditions, energy is proportional to the wave height. Under other conditions, wave energy is proportional to the number of pulses per unit time.

Waves are periodic moving pulses of energy. The shape, or form, of a wave is to some degree determined by the medium through which the wave travels.

Section Objectives

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

1. Identify a pulse and a periodic wave.
2. Calculate the velocity, frequency, period, and length of a wave.
3. Identify and generate transverse waves and longitudinal waves.
4. To describe the properties of a torsional wave.

Vocabulary

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

amplitude	**condensation**	**crest**	**frequency**
longitudinal wave	**nonrecurrent wave**	**period**	**periodic wave**
pulse	**rarefaction**	**torsional wave**	**transverse wave**
trough	**velocity**	**wave**	**wavelength**

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.*

MECHANICAL ENERGY

Energy is the ability to do work. **Work** occurs whenever a **force** (F) is exerted through a **distance** (d). The product of the net force and the **displacement** through which it is exerted is work.

work = F • d

Net force means that if more than one force is acting upon an object, the *vector sum* must be obtained.

The displacement through which the force acts is parallel to the direction of the force. (Trigonometry is used to solve problems involving forces not parallel to the displacement.) If the force were perpendicular to the displacement, the object would not move in a straight line but would rotate in a circular path.

Mechanical energy has two forms, kinetic and potential. These two forms are the subject of this section.

Kinetic energy. An object in motion can do work by virtue of its motion because it can exert a force through a distance. The energy it has due to its motion is called **kinetic energy**.

Kinetic energy = $\frac{1}{2} mv^2$

where *m* is the **mass** of the object and *v* is its velocity.

Since kinetic energy results from a force acting over a certain distance,

$F \cdot d = \frac{1}{2} mv^2$

This equation could have been derived from Newton's second law:

$F = ma$
$F \cdot d = mad$

| Baseball pitchers apply force on the ball to get the ball over home plate.

Since $d = \frac{1}{2} at^2$,

$F \cdot d = ma(\frac{1}{2}at^2) = \frac{1}{2}ma^2t^2$

Substituting $v = at$,

$F \cdot d = \frac{1}{2}mv^2$

Complete these activities.

1.1 A car traveling at 60 mph has how much more energy than a car going at 20 mph?

1.2 How much farther will a car skid if it locks its brakes at 60 mph as compared to a skid from 15 mph?

The velocity of a wave may be determined by multiplying its frequency times its wavelength.

$$V = f\lambda$$

The frequency and period are reciprocals of each other.

$$f = {}^1/_T \text{ or } T = {}^1/_f$$

Complete these activities.

1.7 Waves are observed passing under a dock. Wave crests are eight meters apart. The time for a complete wave to pass by is four seconds. The markings on the post submerged in water indicate that the water level fluctuates from a trough at six meters to a crest at nine meters.

a. What is the amplitude of the wave? ______________________

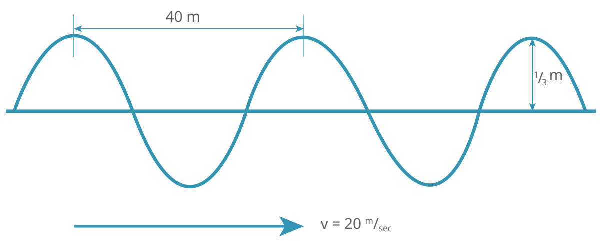
b. What is the wavelength of the wave? ______________________

c. What is the period of the wave? ______________________

d. What is the frequency of the wave? ______________________

e. Calculate the velocity of the wave. ______________________

1.8 Answer the questions based on this wave form.

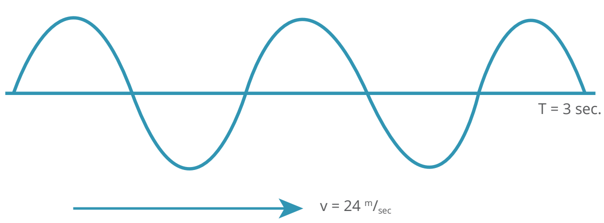


a. What is the distance from crest to trough (2A)? ______________________

b. What is the frequency of the wave? ______________________

c. What is the period of a wave? ______________________

1.9 A wave has a velocity of 24 m/sec. and a period of 3 sec.



a. What is the frequency of the wave? ______________________

b. Calculate the wavelength of the wave. ______________________

c. Can the amplitude be determined from the given information?

____

____

Try this investigation. You will study the angles that light makes as it is incident on a mirror.

These supplies are needed:

- mirror
- ruler
- pencil
- protractor
- flashlight or laser pointer
- ball bearing
- sheet of paper

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

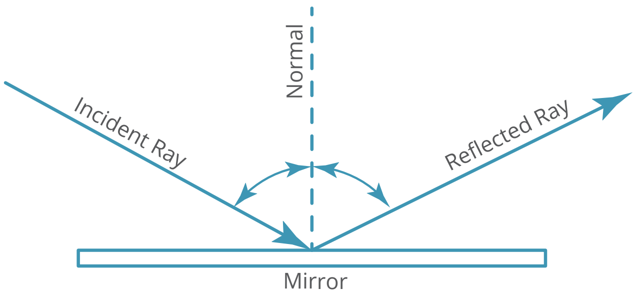
☐ 1. Shine a pencil-thin beam of light on a mirror perpendicular to its surface.

1.6 How does the light reflect? ______________________________

1.7 How does the relationship of incident to reflected ray relate to the reflection of water waves moving perpendicular to a barrier?

____

☐ 2. Shine a pencil-thin beam of light on a mirror standing on a sheet of paper on the table (or floor) so that you can mark the incident ray and reflected ray.



☐ 3. Mark a line on the paper representing the reflective surface. (The reflective surface of a mirror is usually the back edge.)

☐ 4. Draw a dashed line perpendicular to the mirror surface at a point where the incident and reflected ray meet. This perpendicular is called a **normal** to the surface.

☐ 5. Measure the angles between the rays and the normal. The **angle of incidence** is the angle formed by the incident ray and the normal to the surface. The angle formed by the reflected ray and normal is called the **angle of reflection** (*r*).

1.8 What is the angle of incidence? ______________________________

1.9 What is the angle of reflection? ______________________________

☐ 6. Repeat for several different angles.

1.10 What appears to be the relationship between the angle of incidence and angle of reflection?

____

1.11 In Science LIFEPAC 1204 what was the relationship for these two angles made by the reflection of waves in a ripple tank?

____

Reflection of Light Experiment (Continued on next page)

When Gilbert touched (grounded) the spheres with his hand, they returned to their normal positions.

He then rubbed the wand with the fur again, but this time he touched the fur against the spheres. They again became charged and repelled each other.

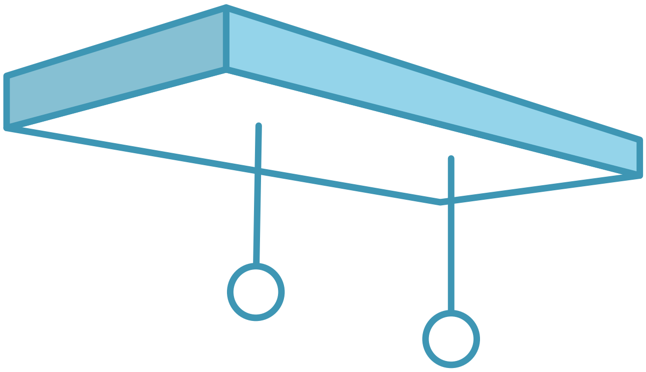
He tried one other experiment, this time touching one sphere with the wand and the other with the fur. The result was that the spheres now attracted each other.

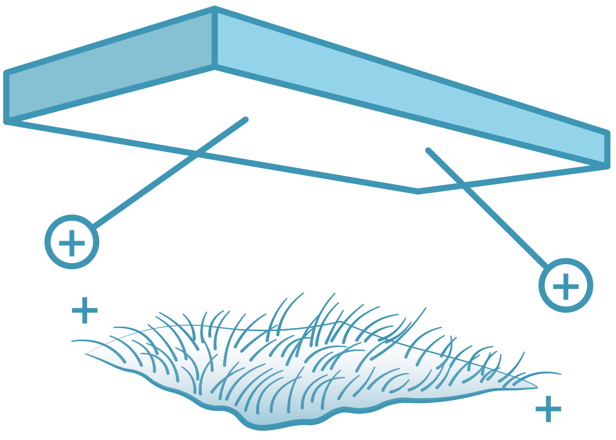
Gilbert concluded that the two charges must be different, and thus that charges occur in two varieties.

Gilbert performed experiments using a glass wand and a silk handkerchief and found that the effects were repeated even though the rubber wand and fur were not used. The properties of electrical charge were thus not limited to the use of the rubber and fur. Gilbert found that a glass wand produced a charge *opposite* to that produced by the rubber wand.

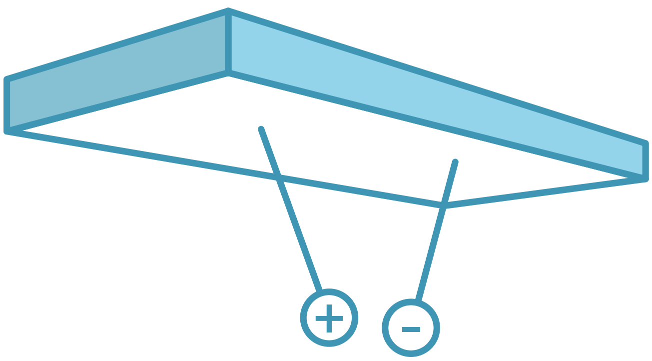
In the late eighteenth century, the American scientist and statesman, Benjamin Franklin, gave names to the electrical charges studied by Gilbert. Franklin called the charge from the fur and the glass rod, *positive*; and the charge on the rubber wand, *negative*. This designation is still in use today. All electrically charged bodies are either negative or positive. The early experiments, however, did not indicate the nature of an electrical charge.

You may have experienced this same process after walking across a rug and getting a shock when you touched the doorknob. The same electrical charge may build up in a clothes dryer. Some fabrics are able to separate the electrical charge into positive and negative portions. The friction of two objects rubbing against each other causes the separation of electricity into the positive and negative parts. Some objects are **insulators** and do not distribute or communicate a charge to any other part of their bodies.





(charged)



Complete these sentences.

1.5 The phenomenon that describes the emission of electrons from a metal surface when light shines on it is the ______________________________ .

1.6 The maximum energy of photoelectrons a. ______________________ with frequency and b. ______________________ with increasing intensity of the light. (increases, decreases, remains constant)

1.7 Photon energy is proportional to ______________________ .

1.8 Photons are also known as ______________________ .

Solve these problems.

1.9 A yellow lamp emits light with a wavelength of $6 \cdot 10^{-7}$ m.

a. Write the common value for the speed of light, in meters per second.

b. Calculate the frequency of the yellow light from the equation given in Science LIFEPAC 1204.

c. Use Planck's equation to calculate the energy of a single photon with the given wavelength.

d. How many such photons are required to produce 10 joules?

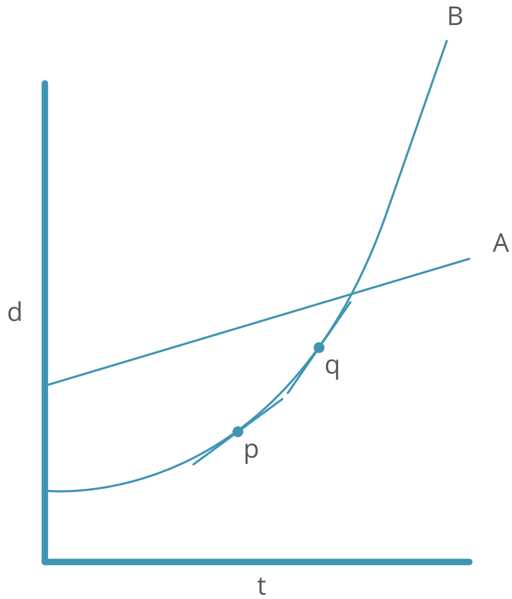
1.10 A 10,000 watt radio station transmits at 880 kHz.

a. Determine the number of joules transmitted per second.

b. Calculate the energy of a single photon at the transmitted frequency.

c. Calculate the number of photons that are emitted per second.

Velocity is the slope of a displacement-time graph:

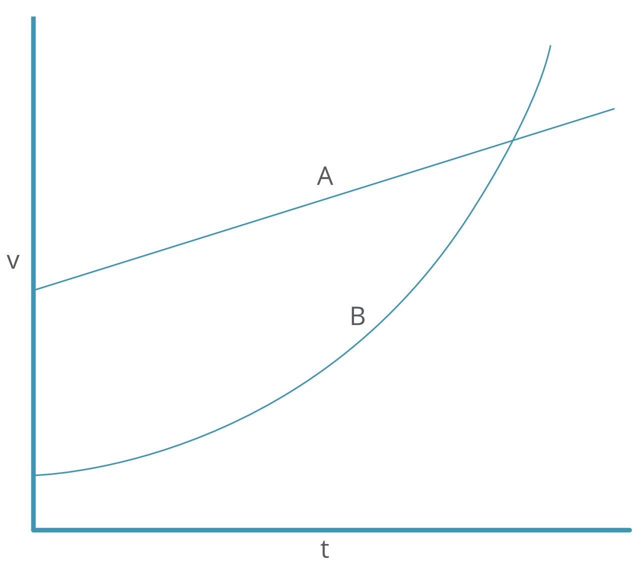


Curve A represents constant velocity because the slope $\Delta d/\Delta t$ is uniform. Curve B represents increasing velocity because the slope at Point q is greater than the slope at Point p.

Acceleration. The rate of change in velocity with respect to time is acceleration. A greater velocity change in a given period of time or the same velocity change in a shorter period of time produces an increase in acceleration. The reverse cases produce a decrease in acceleration.

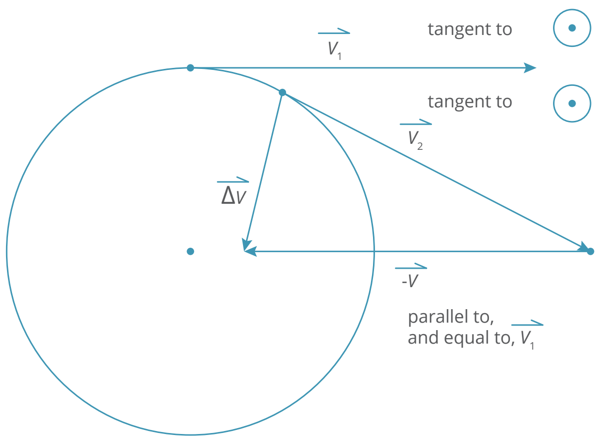
$$a = \Delta v/\Delta t$$

Acceleration is the slope of a velocity-time graph:



Curve A represents constant acceleration because the slope $\Delta v/\Delta t$ is uniform. Curve B represents increasing acceleration.

Velocity is a vector quantity. If the *magnitude* of the velocity (the speed) remains constant but its direction changes, this change in velocity, by definition, constitutes acceleration. Motion of an object in a circular path is *centripetal* acceleration.



When velocity vectors on a circular path are taken infinitely close together, the centripetal ("center-seeking") acceleration vector points to the center of the circle.

The magnitude of centripetal acceleration is proportional not to velocity but to velocity squared,

$$a \propto v^2$$

and is inversely proportional to the radius of the curve,

$$a \propto {}^{1}\!/_{R}$$

Combining these two formulas, the result is

$$a \propto {}^{v^2}\!/_{R}$$

When a car turns a corner, the car is harder to control; and the centripetal acceleration is increased if the speed is increased or if speed is maintained on a curve with a smaller radius. Rollovers occur at high speeds on sharp turns.

As the velocity changes, the acceleration changes in ratios of 2:4, 3:9, 4:16, 5:25, and so on. Notice that the change in acceleration is as the square of the velocity. The radius of the curve, however, affects the centripetal acceleration in this manner ⅓:3, ½:2, 2:½, 4:¼. Therefore, if the car turns in a larger arc (double the radius) and doubles the speed, the acceleration is decreased by half because of the greater arc; but the acceleration is increased by a factor of four because of the greater speed.

LIFEPAC®

SCIENCE

TEACHER'S GUIDE

12th Grade

LIFEPAC | aop.com

Alpha Omega PUBLICATIONS

SCIENCE 1200

Teacher's Guide

INSTRUCTIONS FOR SCIENCE

The LIFEPAC curriculum from grades 2 through 12 is structured so that the daily instructional material is written directly into the LIFEPACs. The student is encouraged to read and follow this instructional material in order to develop independent study habits. The teacher should introduce the LIFEPAC to the student, set a required completion schedule, complete teacher checks, be available for questions regarding both content and procedures, administer and grade tests, and develop additional learning activities as desired. Teachers working with several students may schedule their time so that students are assigned to a quiet work activity when it is necessary to spend instructional time with one particular student.

The Teacher Notes section of the Teacher's Guide lists the required or suggested materials for the LIFEPACs and provides additional learning activities for the students. The materials section refers only to LIFEPAC materials and does not include materials which may be needed for the additional activities. Additional learning activities provide a change from the daily school routine, encourage the student's interest in learning and may be used as a reward for good study habits.

If you have limited facilities and are not able to perform all the experiments contained in the LIFEPAC curriculum, the Science Project List may be a useful tool for you. This list prioritizes experiments into three categories: those essential to perform, those which should be performed as time and facilities permit, and those not essential for mastery of LIFEPACs. Of course, for complete understanding of concepts and student participation in the curriculum, all experiments should be performed whenever practical. Materials for the experiments are shown in Teacher Notes—Materials Needed.

Videos of many of the labs may be available from online sources. These are useful as a demonstration of the lab procedure and for suggestions on alternate materials and equipment that can be used.

NOTE: Data tables and formulas can be found throughout the curriculum. They should be available to the students (where appropriate) any time they are answering problems in section exercises, self tests, or LIFEPAC tests.

SCIENCE PROJECTS LIST

Key

(1) = Those essential to perform for basic understanding of scientific principles.

(2) = Those which should be performed as time permits.

(3) = Those not essential for mastery of LIFEPACs.

S = Equipment needed for homeschool or Christian school lab.

E = Explanation or demonstration by instructor may replace student or class lab work.

H = Suitable for homework or for homeschool students. (No lab equipment needed.)

Science 1201

pp	7	(1)	S
	15	(1)	S
	22	(1)	S
	36	(1)	S
	42	(1)	S
	44	(1)	S

Science 1202

pp	9	(1)	S
	29	(1)	S
	38	(1)	S
	40	(1)	S
	47	(2)	H

Science 1203

pp	18	(1)	S
	23	(1)	H
	33	(2)	S

Science 1204

pp	6	(1)	S or H
	8	(1)	S or H
	10	(1)	S
	11	(2)	S
	17	(1)	S
	18	(1)	S or H
	19	(1)	S
	21	(1)	S or H
	23	(1)	S
	24	(1)	S or H
	26	(1)	S or H
	27	(1)	S
	36	(1)	S
	37	(1)	S
	38	(1)	S

Science 1205

pp	8	(1)	S or H
	10	(1)	S or H
	11	(1)	S or H
	13	(1)	S
	16	(1)	S or H
	18	(1)	S
	24	(1)	S or H
	28	(1)	S
	31	(1)	S or H
	38	(1)	S or H
	41	(1)	S or H

Science 1206

pp	10	(1)	S or H

Science 1207

none

Science 1208

pp	8	(2)	S or H
	17	(1)	S or H

Science 1209

none

Science 1210

none

TEACHER NOTES

MATERIALS NEEDED FOR LIFEPAC	
Required	**Suggested**
• Section 1: screw, paper straw, 2 microscope slides, needle, ruler, razor blade, wood block, tongue depressor, clothespin, paper • Section 2: 100-cc graduated cylinder, 50-cc graduated cylinder, large tray, 2 eyedroppers, talcum powder, oleic acid, alcohol, meter stick • Section 3: C-clamp, spark timer, timer tape, ruler • Section 4: spark timer, timer tape, ruler, C-clamp • Section 5: 15 to 30 thermometers, 3 acetate sheets, roll of adding machine tape, meter stick	(none)

Additional Activities

The following activities may be reproduced as student worksheets.

» SECTION 1: UNITS, SCALARS, AND VECTORS

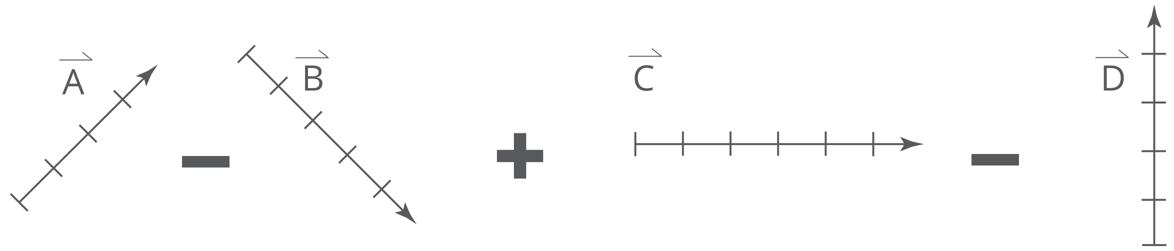
1. Calculate $1.8 \cdot 10^{4}$ times $4 \cdot 10^{-6}$ divided by $3 \cdot 10^{2}$.

2. Calculate $7 \cdot 10^{-2}$ times $4 \cdot 10^{-3}$ divided by $5 \cdot 10^{-7}$.

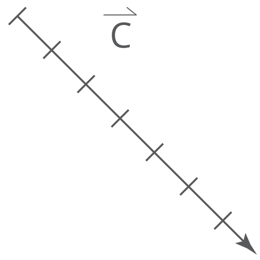
3. Express $5 \cdot 10^{5}$ m in km.

4. Express $3.2 \cdot 10^{2}$ m in cm.

5. Add these vectors.



6. Find the vertical and horizontal components of C.



Additional Activities, Answer Key

Section 1: Units, Scalars, and Vectors

1. $\dfrac{(1.8 \cdot 10^4)(4 \cdot 10^{-6})}{3 \cdot 10^2} = \dfrac{(1.8)(4)}{3} \cdot 10^{4-6-2}$

$= 2.4 \cdot 10^{-4}$

2. $\dfrac{(7 \cdot 10^{-2})(4 \cdot 10^{-3})}{5 \cdot 10^{-7}} = \dfrac{(7)(4)}{5} \cdot 10^{-2-3-(-7)}$

$= \dfrac{28}{5} \cdot 10^2 = 5.6 \cdot 10^2$

3. $5 \cdot 10^5 \text{ m} = 5 \cdot 10^2 \cdot 10^3 \text{ m} = 5 \cdot 10^2 \text{ km}$

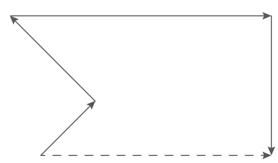
$= 500 \text{ km}$

4. $3.2 \cdot 10^2 \text{ m} = 3.2 \cdot 10^2 \cdot (10^{+2} \cdot 10^{-2}) \text{ m}$

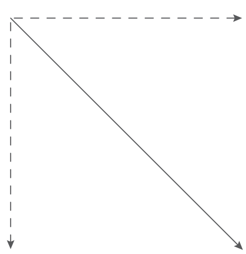
$= 3.2 \cdot 10^2 \cdot 10^2 \text{ cm}$

$= 3.2 \cdot 10^4 \text{ cm}$

5.

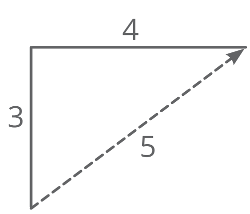


6.



Section 2: Measurement of Length

1.



distance is 3 + 4 blocks = 7 blocks

displacement is $\sqrt{3^2 + 4^2} = 5$

2. a. $A = l \cdot w$ 4 cm • 5 cm = 20 cm^2

b. $V = l \cdot w \cdot h$ 4 cm • 5 cm • 2 cm = 40 cm^3

c. $\text{Density} = \dfrac{\text{Mass}}{\text{Volume}} = \dfrac{8 \text{ g}}{40 \text{ cm}^3} = \dfrac{5 \text{ g}}{\text{cc}}$

Section 3: Rate of Length Change

1. a. $S = \dfrac{\Delta d}{\Delta t} = \dfrac{100 \text{ mi}}{2 \text{ hr}} = 50 \text{ mph}$

b. $v = \dfrac{\Delta d}{\Delta t} = \dfrac{80 \text{ mi north}}{2 \text{ hr}} = 40 \text{ mph, north}$

Section 4: Rate of Velocity

1. $a = \dfrac{v^2}{R} = \dfrac{(30 \frac{\text{ft}}{\text{sec}})(30 \frac{\text{ft}}{\text{sec}})}{9 \text{ ft}} = \dfrac{900 \frac{\text{ft}^2}{\text{sec}^2}}{9 \text{ ft}}$

$= 100 \dfrac{\text{ft}}{\text{sec}^2}$, direction is always toward the center

2. $a = \dfrac{\Delta v}{\Delta t} = \dfrac{70 \frac{\text{m}}{\text{sec}} - 60 \frac{\text{m}}{\text{sec}}, \text{NE}}{5 \text{ sec}}$

$= \dfrac{10 \frac{\text{m}}{\text{sec}}}{5 \text{ sec}}, \text{NE} = 2 \dfrac{\text{m}}{\text{sec}^2}, \text{NE}$

3. $d = \dfrac{1}{2}gt^2 = \dfrac{1}{2}(32 \dfrac{\text{ft}}{\text{sec}^2})(4 \text{ sec})^2$

$= 16 \cdot 16 \dfrac{\text{ft}}{\text{sec}^2}$

$= 256 \dfrac{\text{ft}}{\text{sec}^2}$

$d = \dfrac{1}{2}\text{g}t^2 = \dfrac{1}{2}(9.8 \dfrac{\text{m}}{\text{sec}^2})(4 \text{ sec})^2$

$= (4.9)(16) \dfrac{\text{m}}{\text{sec}^2}$

$= 78.4 \dfrac{\text{m}}{\text{sec}^2}$

5.15 No, they are mental constructs which may take on physical dimensions.

5.16 The model of an atom tries to convey the region where the particle might be located, its interaction with other parts, its occupation of space or volume, its electrical charge and nuclear forces along with electrical forces and also its chemical activity.

SELF TEST 5

5.01 b
5.02 j
5.03 a
5.04 e
5.05 d
5.06 g
5.07 k
5.08 i
5.09 c
5.010 h

5.011 $\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v} \text{ final} - \vec{v} \text{ initial}}{\Delta t}$

$= \frac{10 \text{ m/s} - 20 \text{ m/s}}{5 \text{ s}}$

$= \frac{-10 \text{ m/s}}{5 \text{ s}}$

$= -2 \text{ m/s}^2$, a negative acceleration

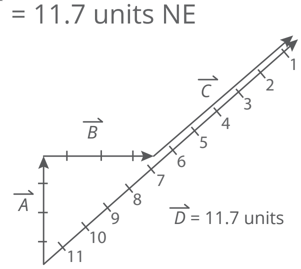
5.012

35 mph × 1 hr	= 35 miles;	1 hr
40 mph × ½ hr	= 20 miles;	½ hr
50 mph × 2 hr	= 100 miles;	2 hr
	155 miles	3½ hr

$\text{speed} = \frac{\Delta d}{\Delta t} = \frac{155 \text{ miles}}{3.5 \text{ hr}}$

speed = 44.3 mph

5.013 $\vec{D}$ = 11.7 units NE



5.014 1
5.015 3.2×10^5 cm
5.016 Mass and time; they do not depend on direction
5.017 An object at rest stays at rest or an object in motion stays in motion unless there are unbalanced external forces acting on it.
5.018 Because at every point in a region of space there is a value for temperature as recorded on a thermometer.
5.019 A resultant occurs by combining (add or subtract) two or more vectors and a component occurs when you take one vector and split it into its horizontal and vertical vectors.
5.020 Example:
Molecules like tiny BBs moving rapidly around and colliding with each other.

SCIENCE 1201

ALTERNATE LIFEPAC TEST

54/67

NAME ________________

DATE ________________

SCORE ________________

Match these items (each answer, 2 points).

1. ________ The fundamental unit on this list that is synonymous with mass.
2. ________ As a car slows down it undergoes ______ .
3. ________ The term that describes 400 miles by road between two cities.
4. ________ Traveling in one direction (north), the car's rate of distance changes as the time fluctuates. The average calculated is ______ .
5. ________ Distance is what kind of quantity?
6. ________ A plane travels 300 mph east; what term best describes this derived quantity?

a. inertia
b. distance
c. displacement
d. scalar
e. acceleration
f. average velocity
g. velocity

Complete these calculations (each answer, 5 points).

7. A car travels from City A eastward to City B. It takes 8 hours, and the road is 400 miles long, although it is only 320 miles between cities in a straight line. What is the average speed of the car?

Answer these questions (each answer, 5 points).

13. Near the surface of the earth, the temperature decreases at high altitudes. Also, temperatures differ over land or water surfaces and change from night to day. Explain how you can describe the earth's atmosphere in terms of a temperature field. What are the difficulties involved?

14. What are the advantages and disadvantages of using a globe in describing the earth to an elementary school child?