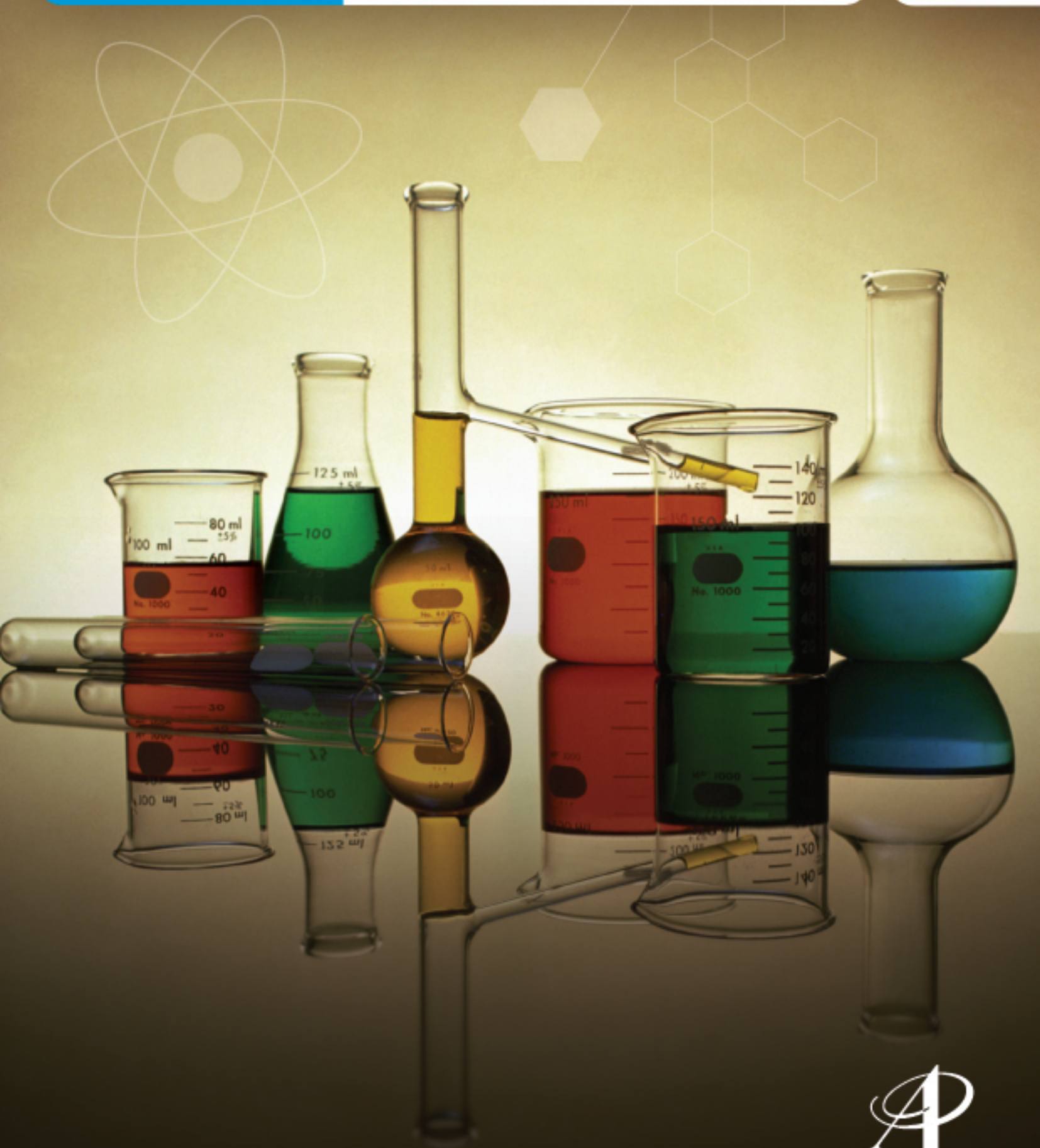
LIFEPAC®

Science



Alpha Omega Publications®

SCIENCE 1202
DYNAMICS

CONTENTS

Author: **Mary Grace Ferriera, M.A.T., M.N.S.**
Editor: Alan Christopherson, M.S.
Illustrations: Jim Lahowetz
Alpha Omega Graphics

Alpha Omega Publications®
804 N. 2nd Ave. E., Rock Rapids, IA 51246-1759

DYNAMICS

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 about 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.

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

I. NEWTON'S FIRST AND SECOND LAWS OF MOTION

To begin a study of dynamics, you will become acquainted with Sir Isaac Newton and his laws of motion. Newton once stated that he had made strides in physics only because he had stood on the shoulders of a giant—Galileo Galilei. As we investigate the first two laws of motion, review the law of inertia from the previous LIFEPAC.

SECTION OBJECTIVES

Review these objectives. When you have completed this section, 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.

VOCABULARY

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

force
impulse
momentum
Newton's first law of motion
Newton's second law of motion

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.

NEWTON'S FIRST LAW OF MOTION

Isaac Newton (1642-1727) was born the year that Galileo Galilei died, and at age twenty-three, formulated his laws of motion. Galileo's law of inertia is a special case of **Newton's first law of motion**, which, when translated from Newton's *Principia*, states:

"Every object continues in its state of rest or of uniform motion in a straight line unless it is compelled to change that state by **forces** acting on it."

The key word is *continues*: the object continues to do whatever it is doing unless a force acts on it. A force is a push or a pull: that which causes an object to be accelerated. If the object is stationary, it will remain stationary; and if it is moving, it will continue to move without changing direction or speed; that is, *it does not accelerate*. The tendency of a body to resist a change in motion is what Galileo termed *inertia*.

Prepare a report.

1.1 Newton stated that, if he had made any strides in science, he had done so by standing on the shoulders of a giant named Galileo Galilei. This statement was modest coming from a man who made discoveries in so many different areas of physics. Prepare a report on the life of Sir Isaac Newton, his accomplishments, discoveries, books written, and honors received. Submit the report for evaluation.

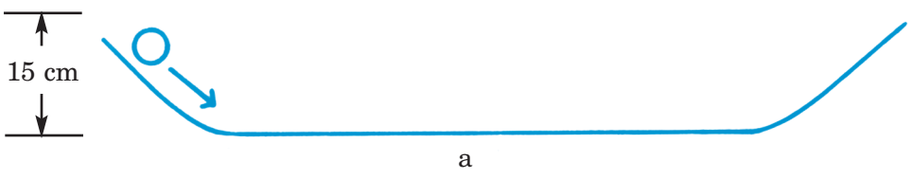
Score _____

Adult check _____

Initial **Date**

Complete these calculations.

1.2 In this activity assume that the effect of friction can be discounted.



a

a. Referring to diagram *a*, how high will the ball rise on the right-hand incline?

b

b. Referring to diagram *b*, if the incline on the right has a slope of 5 cm of rise for each 2 cm of run, how far will the ball travel horizontally? _____

c. If, in *b*, the rise is only 0.5 cm for each 2 cm of run, how far will the ball travel horizontally? _____

d. If, in *b*, the rise is 0.01 cm for each 2 cm of run, how far will the ball travel horizontally?

_____

e. If, in *b*, no gravitational force retarded the ball's movement (that is, if the right hand side of the diagram were horizontal), how far would the ball travel? _____

1.3 If a ball is given an initial speed of 15 $^{m}/_{sec}$ on a horizontal, frictionless surface, how fast will the ball be rolling in 5 seconds? _____

1.4 A car moves down the street at 45 kph. The driver takes his foot off the gas pedal but does not brake. Explain why the car slows down. _____

_____

NEWTON'S SECOND LAW OF MOTION

Nearly everyone has had at least one experience of helping push a friend's car to a garage or gas station. If you have enough friends in this situation, you know that pushing a light car is easier than pushing a heavier one. If a detailed study is made, a relationship is discovered: The acceleration of an object is directly proportional to the net force acting on the object, and is inversely proportional to the mass of the object. This relationship is called **Newton's second law of motion**.

Force. To move an object from rest to a certain velocity requires an acceleration: $a = {}^{\Delta v}/_{\Delta t}$. If more than one force is exerted, the total, or net, force is the vector sum of all the forces. The greater the net force, the greater the acceleration. This relationship is called a *direct proportion*. That is, when one quantity increases, the other increases by the same proportion.

If the mass of the object is increased, the same force produces a smaller acceleration. In fact, doubling the mass produces half the acceleration previously attained, and tripling the mass yields only one-third of the former acceleration. This relationship is called an *inverse proportion*. We can write Newton's Second Law as $a = {}^{F}/_{m}$, By cross multiplying we obtain $F = ma$.

Impulse and momentum. If in the formula $F = ma$, a is replaced by $^{\Delta v}/_{\Delta t}$ then $F = m\ {}^{\Delta v}/_{\Delta t}$ and $F\Delta t = m\Delta v$.

This last equation, derived from Newton's Second Law, is rather important. The term on the left, $F\Delta t$, is called the **impulse**, which is the product of the force on an object and the time during which the force acts. When a bat hits a baseball, a tennis racket hits a tennis ball, an oar pushes against water, or a foot pushes against the ground, an impulse is imparted that equals force times the lapsed time. The smaller the force, the smaller the impulse; the shorter the time, the smaller the impulse. The metric unit of impulse is the newton-second (N•sec), or the kilogram-meter/second ($kg\bullet {}^{m}/_{sec}$).

The term on the right is called the **momentum**, which is the product of the mass and its change in velocity. Momentum is not speed, velocity, force, nor energy. Let us look at some examples that convey the concept of momentum. A turtle moving at a meter per minute is not a formidable object. But