NEWTON'S LAWS OF MOTION

CHP 6: LITTLE BOOK ANSWERS

Forces: Balanced or Unbalanced?

Calculate the net force for each. Remember to add forces in the same direction & subtract forces in the opposite direction. Please include units.

	Force 1	Force 2	Net Force & Direction	Balanced or Unbalanced? B or U?
1	1 N east	1 N east	2 N east	U
2	10 N north	10 N south	0 N	B
3	5 N left	4.3 N left	9.3 N LEFT	U
4	36 N up	36 N down	0 N	B
5	25 N right	25 N right	50 N RIGHT	U
6	46 N left	43 N right	3N LEFT	U
7	9.5 N down	9.5 N up	0 N	B
8	23 N right	13 N right	36 N RIGHT	U
9	3.6 N left	2.5 N right	1.1 N LEFT	U
10	14.5 N down	14.5 N up	0 N	B

WORKSHEET 48 — MATH IN SCIENCE: PHYSICAL SCIENCE

Math Basics Check: Subtraction, Multiplication, Decimals, Scientific Notation

Newton: Force and Motion

Use the equations for acceleration and Newton's second law to learn about the motions and forces in the world around us.

In the seventeenth century, a brilliant young scientist named Isaac Newton explained the relationship between force, mass, and acceleration. This simple relationship describes much of the force and motion in the universe, from a tossed baseball to the motion of the stars and planets.

Part 1: Acceleration

Have you ever seen the start of an auto race? In one instant, the cars are practically motionless. The next instant, they are almost flying around the track. What acceleration! But did you know that as a speeding car slows to turn, it is also accelerating? **Acceleration** is defined as the rate at which the velocity of an object changes. In other words, acceleration is a measure of how quickly something speeds up *or* slows down. The equation for acceleration is given below.

EQUATION: change in velocity = final velocity − initial velocity

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

SAMPLE PROBLEM: What is the acceleration of an in-line skater who increases her velocity from 3.5 m/s forward to 6 m/s forward in 2 seconds?

change in velocity = 6 m/s − 3.5 m/s = 2.5 m/s

$$\text{acceleration} = \frac{2.5\ \text{m/s}}{2\ \text{s}}$$

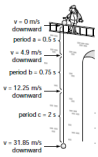
acceleration = **1.25 m/s² forward**

1. Calculate the acceleration of the ball for each time period that it falls.

a. 9.8 m/s² downward

b. 9.8 m/s² downward

c. 9.8 m/s² downward



Challenge Yourself!

2. A jet flying at 200 m/s north accelerates at a rate of 18.2 m/s² for 15 seconds. What is the jet's final velocity?

18.2 m/s² × 15 seconds = 273 m/s

273 m/s + 200 m/s = 473 m/s north

Part 2: Newton's Second Law

Isaac Newton expressed the relationship between force, mass, and acceleration in his second law. This law is so important that it became the basis for much of modern physics. In fact, Newton's contribution to science was so great that the unit for force, the newton (N), was named after him. A newton is defined as the force needed to produce an acceleration of 1 m/s² on a 1 kg object. Therefore, 1 N = 1 kg × 1 m/s². The equation for Newton's second law is given below.

EQUATION: Force = mass × acceleration

$$F = m \times a$$

If you know two of the values in this equation, you can calculate the third by changing the equation around, as follows:

$$\text{acceleration} = \frac{\text{Force}}{\text{mass}} \quad \text{and} \quad \text{mass} = \frac{\text{Force}}{\text{acceleration}}$$

SAMPLE PROBLEM: A soccer ball accelerates at a rate of 22 m/s² forward when kicked by a player. The soccer ball has a mass of 0.5 kg. How much force was applied to the ball to produce this acceleration?

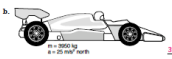
Force = mass × acceleration
Force = 0.5 kg × 22 m/s²
Force = 11 kg × m/s²
Force = **11 N**

Use the equations above to complete the following problems:

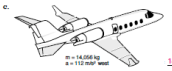
2. Calculate the force necessary to accelerate the following vehicles at the rate of acceleration shown in the illustration.

a. 

Force = 115 kg × 6 m/s² = 690 N

b. 

3950 kg × 25 m/s² = 98,750 N

c. 

14,066 kg × 112 m/s² = 1,574,272 N

3. How much force is needed to move a 0.1 kg snowball at a rate of 15 m/s² upward?

0.1 kg × 15 m/s² = 1.5 N

4. A 0.02 N push accelerates a table-tennis ball along a table at 8 m/s² north. What is the mass of the ball?

0.02 N ÷ 8 m/s² = 0.0025 kg

5. At lift-off, an astronaut on the space shuttle experiences an acceleration of approximately 35 m/s² upward. What force does an 80 kg astronaut experience during this acceleration?

80 kg × 35 m/s² = 2800 N

6. What is the acceleration of a train with a mass of 3.2×10^6 kg that pushes itself forward with a 2.4×10^{19} N of force?

(2.4×10^{19}) N ÷ (3.2×10^6) kg = $0.75 \times 10 = 7.5$; 7.5 m/s² forward

Part 3: The Force of Gravity

Forces are not always exerted on objects by direct physical contact, such as a hand pushing a door closed. For instance, the Earth exerts the force of gravity on objects even when the objects are not directly touching the ground. The acceleration on an object due to the force of gravity is 9.8 m/s² downward. In other words, for every second an object is falling, its velocity increases by 9.8 m/s downward.

7. a. A 9 kg bowling ball rolls off a table and strikes the ground. If the ball is in the air for 0.5 seconds, how fast is the ball moving when it hits the ground?

0.5 s × 9.8 m/s² = 4.9 m/s downward

b. Another bowling ball with one-fifth less mass rolls off the same table and strikes the ground. When this ball hits the ground, is it moving faster, slower, or the same speed as the first ball? Explain your answer.

The ball with less mass will be traveling the same velocity (4.9 m/s downward) as the first ball.

The difference in mass does not affect the acceleration due to gravity.

Chapter Review

USING VOCABULARY

To complete the following sentences, choose the correct term from each pair of terms listed below, and write the term in the space provided.

1. An object in motion tends to stay in motion because it has _____ inertia _____. (inertia or terminal velocity)
2. Falling objects stop accelerating at _____ terminal velocity _____. (free fall or terminal velocity)
3. _____ Projectile motion _____ is the path that a thrown object follows. (Free fall or Projectile motion)
4. A property of moving objects that depends on mass and velocity is _____ momentum _____. (inertia or momentum)
5. _____ Free fall _____ only occurs when there is no air resistance. (Momentum or Free fall)

UNDERSTANDING CONCEPTS

Multiple Choice

6. A feather and a rock dropped at the same time from the same height would land at the same time when dropped by
   a. Galileo in Italy.
   b. Newton in England.
   c. an astronaut on the moon.
   d. an astronaut on the space shuttle.
7. When a soccer ball is kicked, the action and reaction forces do not cancel each other out because
   a. the force of the foot on the ball is bigger than the force of the ball on the foot.
   b. the forces act on two different objects.
   c. the forces act at different times.
   d. All of the above
8. An object is in projectile motion if
   a. it is thrown with a horizontal push.
   b. it is accelerated downward by gravity.
   c. it does not accelerate horizontally.
   d. All of the above
9. Newton's first law of motion applies
   a. to moving objects.
   b. to objects that are not moving.
   c. to objects that are accelerating.
   d. Both (a) and (b)

Chapter review

10. Acceleration of an object
- **a.** decreases as the mass of the object increases.
- **b.** increases as the force on the object increases.
- **c.** is in the same direction as the force on the object.
- **d.** All of the above

11. A golf ball and a bowling ball are moving at the same velocity. Which has more momentum?
- **a.** the golf ball, because it has less mass
- **b.** the bowling ball, because it has more mass
- **c.** They both have the same momentum because they have the same velocity.
- **d.** There is no way to know without additional information.

Short Answer

12. Explain how an orbit is formed.

An orbit is formed by combining the forward motion of the orbiting object with free fall toward Earth. The path that results is a curve that follows the curve of the Earth.

13. Describe how gravity and air resistance combine when an object reaches terminal velocity.

Gravity and air resistance combine to give a net force of zero on a falling object. When this happens, the object stops accelerating downward and has reached its terminal velocity.

14. Explain why friction can make observing Newton's first law of motion difficult.

Friction is a force that opposes the motion of objects. Friction is what slows the motion of moving objects so you don't see objects moving forever in a straight line.