Glencoe Science

Chapter Resources

Newton's Laws of Motion

Includes:

Reproducible Student Pages

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Reproducible Student Pages

Reproducible Student Pages

■ Hands-On Activities

■ Meeting Individual Needs

Extension and Intervention

■ Assessment

■ Transparency Activities

Hands-On Activities

TRY AT HOME Mini LAB

Measuring Motion

Procedure

1. Measure a fixed distance such as the length of your driveway.
2. Use a **watch** to measure the time it takes you to stroll, rapidly walk, and run this distance.

Data and Observations

	Time 1 at Test Distance _______ m	Time 2 at Test Distance _______ m	Time 3 at Test Distance _______ m	Speed
Strolling				
Rapidly walking				
Running				

Analysis

1. Calculate your speed in each case.
2. Use your results to predict how long it would take you to go 100 m by each method.

____

____

Mini LAB

Observing the Laws of Motion

Procedure

1. Incline one end of a **board** to a height of 20 cm.
2. Lay a **meterstick** on the floor with one end flush to the board and place a **softball** where the board and meterstick meet.
3. Hold a **baseball** 10 cm up the slope and roll it into the softball. Measure the distance the softball is pushed. Record your measurements in the table provided.
4. Repeat step 3 from different heights.

Data and Observations

Trial	Height	Distance
Trial 1		
Trial 2		
Trial 3		

Analysis

1. Compare the distances the baseball pushes the softball.

____

____

____

2. Use the laws of motion to explain your results.

____

____

____

LAB Static and Sliding Friction

Lab Preview

Directions: *Answer these questions before you begin the Lab.*

1. What potential hazard do you think there might be from using the materials in this lab?

____

2. How do you think friction might affect Newton's first law?

____

____

Static friction can hold an object in place when you try to push or pull it. Sliding friction explains why you must continually push on something to keep it sliding across a horizontal surface.

Real-World Question

How do the forces of static friction and sliding friction compare?

Materials

spring scale
block of wood or other material
tape

Goals

- **Observe** static and sliding friction.
- **Measure** static and sliding frictional forces.
- **Compare and contrast** static and sliding friction.

Safety Precautions

Procedure

1. Attach a spring scale to the block and set it on the table. Experiment with pulling the block with the scale so you have an idea of how hard you need to pull to start it in motion and continue the motion.
2. **Measure** the force needed to just start the block in motion. This is the force of static friction. Record your measurements in the table.
3. **Measure** the force needed to keep the block moving at a steady speed. This is the force of sliding friction on the block. Record your measurement.
4. Repeat steps 2 and 3 on a different surface, such as carpet. Record your measurements in the table.

Data and Observations

	Force Needed
To start block in motion	
To keep block moving at steady speed	
To start block on carpet	
To keep block moving on carpet	

LAB (continued)

Analyze Your Data

1. **Compare** the forces of static friction and sliding friction on both horizontal surfaces. Which force is greater?

2. On which horizontal surface is the force of static friction greater?

3. On which surface is the force of sliding friction greater?

Conclude and Apply

1. **Draw Conclusions** Which surface is rougher? How do static and sliding friction depend on the roughness of the surface?

2. **Explain** how different materials affect the static and sliding friction between two objects.

Communicating Your Data

Compare your conclusions with those of other students in your class.

Design Your Own

Balanced and Unbalanced Forces

Lab Preview

Directions: *Answer these questions before you begin the Lab.*

1. What materials might you use in this lab to create balanced and unbalanced forces?

____

____

2. What forces are at work when you write on a piece of paper? Are they balanced or unbalanced? Explain.

____

Newton's laws tell you that to change the velocity of an object, there must be an unbalanced force acting on the object. Changing the velocity can involve changing the speed of the object, changing the direction of motion, or changing both.

Real-World Question

How can you apply an unbalanced force to an object? How does the motion change when you exert a force in different ways?

Form a Hypothesis

Predict how the motion of a block will change when different forces are applied to it. Consider both speed and direction.

Goals

- **Describe** how to create balanced and unbalanced forces on an object.
- **Demonstrate** forces that change the speed and the direction of an object's motion.

Safety Precautions

Possible Materials

block
book
pieces of string (2)
spring scales (2)

Test Your Hypothesis

Make a Plan

1. **Describe** how you are going to exert forces on the block using the available materials.
2. **List** several different ways to exert forces or combinations of forces on the block. Think about how strong each force will need to be to change the motion of the block. Include at least one force or combination of forces that you think will not change the object's motion.
3. **Predict** which forces will change the object's direction, its speed, both, or neither. Are the forces balanced or unbalanced?

Check Your Plan

1. Make sure that your teacher approves your plans before going any further.
2. **Compare** your plans for exerting forces with those of others in your class. Discuss why each of you chose the forces you chose.

LAB (continued)

Follow Your Plan

1. Set up your model so that you can exert each of the forces that you listed.
2. **Collect data** by exerting each of the forces in turn and recording how each one affects the object's motion.

Analyze Your Data

1. **Identifying Variables** For each of the forces or combinations of forces that you applied to the object, list all of the forces acting on the object. Was the number of forces acting always the same? Was there a situation when only a single force was being applied? Explain.

___

___

2. **Record Observations** What happened when you exerted balanced forces on the object? Were the results for unbalanced forces the same for different combinations of forces? Why or why not?

___

___

Conclude and Apply

1. Were your predictions correct? Explain how you were able to predict the motion of the block and any mistaken predictions you might have made.

___

___

2. **Summerize** Which of Newton's laws of motion did you demonstrate in this lab?

___

3. **Apply** Suppose you see a pole that is supposed to be vertical, but is starting to tip over. What could you do to prevent the pole from falling over? Describe the forces acting on the pole as it starts to tip and after you do something. Are the forces balanced or unbalanced?

___

___

Communicating Your Data

Compare your results with those of other students in your class. **Discuss** how different combinations of forces affect the motion of the objects.

___

___

___

___

LAB 1 Laboratory Activity

Force, Mass, and Acceleration

An empty truck is driven to a warehouse and picks up a large load. As the truck leaves the warehouse, the driver notices that it takes longer to reach the speed limit on the highway than it did before when the truck was empty. How do you think Newton's second law of motion applies to the truck driver's observations?

Strategy

You will determine the relationship between the force applied to an object and the motion produced by the force.

You will observe and describe how an increase in mass affects the force required to move an object.

You will observe and describe how an increase in force affects the acceleration of an object.

Materials

balance	meterstick	**large metal washers (30)*
books, small (3)	string (150 cm)	**fishing sinkers, 1 oz (30)*
30-g weights with hole (30)	large paper clip	**clock with second hand*
masking tape (60 cm)	stopwatch	**Alternate materials*

Procedure

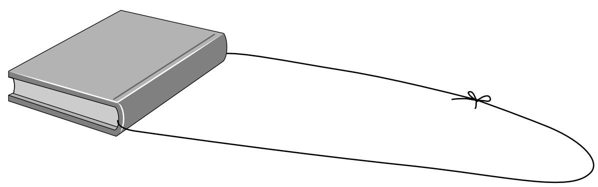
1. Use the balance to determine the mass of each book. Record these masses in Table 1 in the Data and Observations section. From this data, calculate the masses of books 1 and 2 together and of all three books together. Record these masses in the table.
2. Use the balance to determine the mass of 10 weights. Record that mass here.

   Mass of 10 weights ____________

   Divide the mass recorded by 10 to get the average mass of one weight.

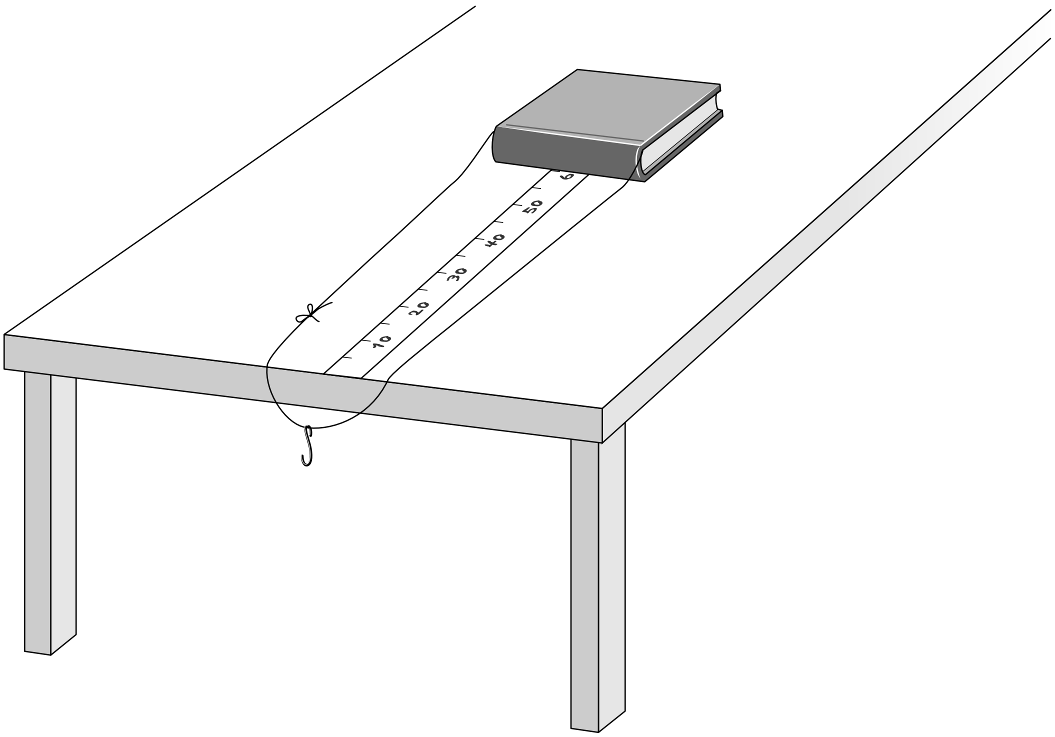
   Mass of 1 weight ____________
3. Place a 60 cm strip of masking tape on a table. Mark the tape in centimeters.
4. Tie the two ends of string together to make a loop.
5. Place the loop of string inside the front cover of one of the books, as shown in Figure 1.
6. Place the book on a tabletop so that some of the string hangs over the edge of the table.
7. Unbend the paper clip to form an "S." Hook one end of the paper clip to the loop of string hanging over the table edge.
8. Slide the book back so the spine of the book is at the 60 cm mark on the masking tape. Your setup should look like Figure 2.
9. Hang weights, one at a time, from the paper clip until the book begins to move toward the edge of the table. Do not let the book slide off the table.
10. Count the number of weights on the paper clip. Calculate the total mass of the weights and record this in Table 1.
11. Calculate the force acting on the book from the weights by multiplying the mass in grams times 0.0098 N/g. Record this force in Table 1.
12. Without removing the weights, slide the book back to the 60 cm mark. Release the book and use the stopwatch to measure the number of seconds it takes for the book to travel 50 cm (to move from the 60 cm mark to the 10 cm mark).

Figure 1



Laboratory Activity 1 (continued)

Figure 2



13. Calculate the acceleration caused by the force and record this in Table 1. The formula for calculating acceleration is given below. In the formula, *a* stands for acceleration, *d* stands for distance, and *t* stands for time. (The distance for each trial is 50 cm, which equals 0.5 m.)

$$a = 2d/t^2$$

14. Repeat steps 8 through 13 using 2 books. Place the second book on top of the book with the loop attached.
15. Repeat steps 8 through 13 using three books. Place the third book on top of the other two books.
16. Repeat steps 12 through 13 three times using one book. For the first trial, use the number of weights you used in step 10. For the second trial, use the number of weights you used for two books. For the third trial, use the number of weights you used for three books. Record the results in the Table 2.

Data and Observations

Table 1

	Mass of books (g)	Mass of weights (g)	Force on book(s) (N)	Time (s)	Acceleration (m/s^2)
Book 1					
Book 1 + 2					
Book 1, 2 + 3					

Laboratory Activity 1 (continued)

Table 2

1 Book	Mass of weights (g)	Force on book (N)	Time (s)	Acceleration (m/s^2)
Trial 1				
Trial 2				
Trial 3				

Questions and Conclusions

1. How does the force needed to move an object change when the mass of an object increases?

2. What happens to the acceleration of an object as the force applied to it increases?

3. Make a graph on the next page of the data from Table 2. Show the force on the *x*-axis and the acceleration produced on the *y*-axis. Use the graph to predict the acceleration that would be caused by a force of 0.5 N.
4. Use the data from Table 1 for the force *(F)* on one book and the acceleration *(a)* of the book to calculate the mass of one book using the formula $F = ma$. The result you calculate should agree with the mass of the book you measured on the balance in step 1. How closely do your results agree? What might be some reasons your results might not agree?

Strategy Check

_______ Can you determine the relationship between the force applied to an object and the motion produced by force?

_______ Can you describe how an increase in mass affects the force required to move an object?

_______ Can you describe how an increase in force affects the acceleration of an object?

Laboratory Activity 1 (continued)

LAB 2 Laboratory Activity

Action and Reaction

The two forces in an action-reaction pair must interact, act in opposite directions, act on different objects in the interaction, and be equal in magnitude. In a rocket, the action force is the force exerted by the rocket that pushes hot gases out the nozzle. The escaping gases cause a reaction force that moves the rocket in the opposite direction. In this activity, you can observe Newton's third law in action.

Strategy

You will make and use a model that illustrates Newton's third law of motion.
You will observe action and reaction related to Newton's third law of motion.
You will identify the forces in an action and reaction.

Materials

plastic drinking straw
scissors
fishing line (3 m)
chairs (2)
long balloons (2)
masking tape
table tennis ball

Procedure

Part A

1. Cut a drinking straw into two equal parts.
2. Slide the fishing line through each piece of straw.
3. Tie each end of the fishing line to the back of a chair. Move the chairs apart so that the fishing line is taut.
4. Move both pieces of straw to one end of the fishing line.
5. Inflate one of the balloons and hold the end closed.
6. Have a partner tape the balloon to the piece of straw farthest away from the chair with the open end of the balloon toward this chair, as shown in Figure 1.
7. Release the balloon and observe what happens. Record your observations in the table in the Data and Observations section.
8. Remove the balloon from the straw. Then repeat steps 5 through 7, but place the straws near the center of the fishing line.

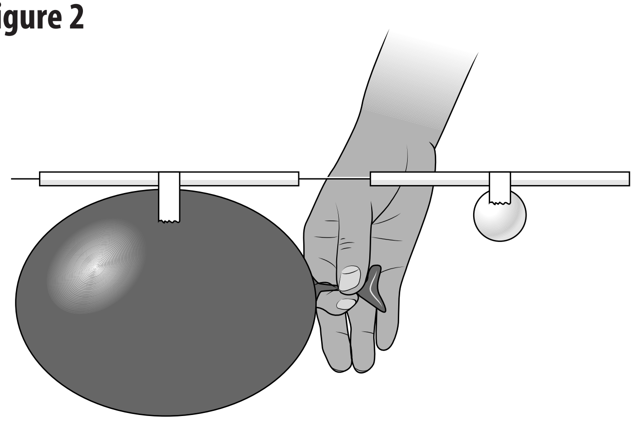
Figure 1

Laboratory Activity 2 (continued)

Part B

1. Repeat step 5 of Part A. Have a partner attach the balloon to a piece of straw near the center of the fishing line. Then have your partner attach a table tennis ball to another piece of straw. The ball should be behind the open end of the balloon, as shown in Figure 2.
2. Release the balloon and observe what happens. Record your observations in the table.
3. Remove the balloon and ball from the fishing line.

Figure 2



Part C

1. Blow up the balloon again and hold the end closed. Have a partner blow up a second balloon and hold its end closed.
2. Have another partner attach both balloons to straws near the center of the fishing line. Place the open end of one balloon near the closed end of the other balloon.
3. Release both balloons at the same time and observe what happens. Record your observations in the table.

Data and Observations

	Observations
One balloon (end of string)	1.
One balloon (center of string)	2.
Balloon and table tennis ball (center of string)	3.
Two balloons (center of string)	4.

Laboratory Activity 2 (continued)

Questions and Conclusions

1. In Part A, compare the direction of the escaping air with the direction of the balloon's movement.

____

2. In Parts A and B, did the escaping air have to hit anything to make the balloon move? Explain.

____

____

3. In Part B, what effect did the escaping air have on the table tennis ball? Use Newton's law to explain why the ball moved as it did.

____

____

____

____

4. Explain the movement of the second balloon in Part C.

____

____

____

____

Strategy Check

_______ Can you make and use a model that illustrates Newton's third law of motion?

_______ Can you observe action and reaction related to Newton's third law?

_______ Can you identify the forces in an action and reaction?

FOLDABLES Reading & Study Skills

Newton's Laws of Motion

Directions: *Use this page to label your Foldable Start Up Activities at the beginning of the chapter.*

Motion

First Law

Second Law

Third Law

Meeting Individual Needs

Directed Reading for Content Mastery

Overview
Newton's Laws of Motion

Directions: *Complete the following sentences.*

1. If you walk from your house to your friend's house, the distance and direction between your house and your friend's house is your ____________________.

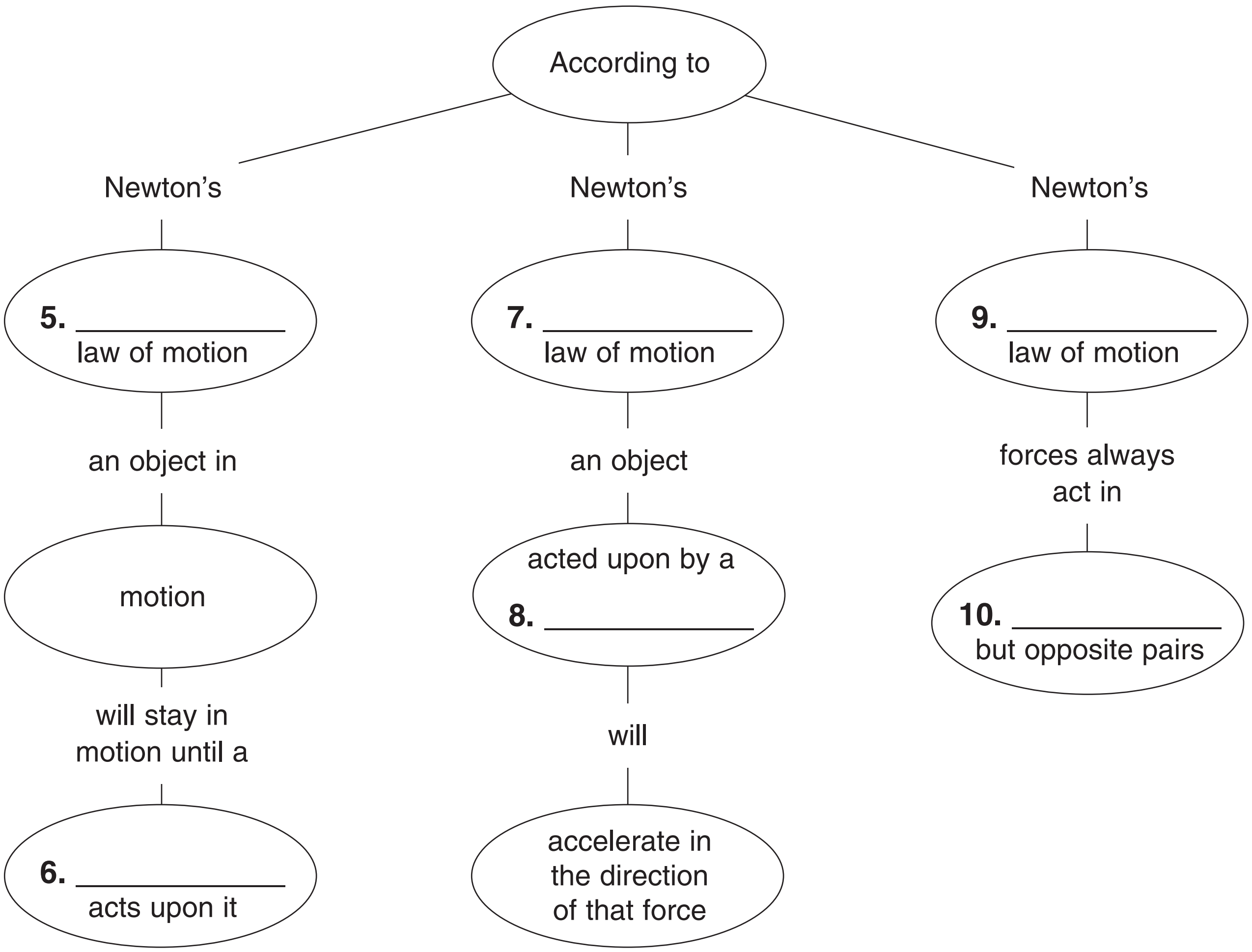
2. The distance traveled divided by the time needed to travel the distance is ____________________.

3. Displacement divided by time is ____________________.

4. Forces that cancel each other out are ____________________.

Directions: *Complete the concept map using the terms below. Some terms may be used more than once.*

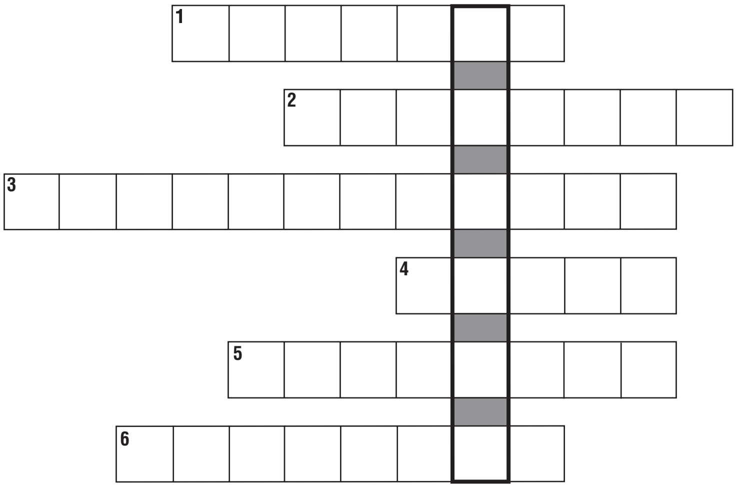
force **second** **first** **equal** **third**



Directed Reading for Content Mastery

Section 1 ■ Motion
Section 2 ■ Newton's First Law

Directions: *Write the term that matches each description in items 1 through 6 below on the spaces provided. Unscramble the boxed letters to spell the term that answers question 7.*



1. A measure of an object's tendency to remain at rest or continue at constant speed
2. How far something travels
3. How far something ends up from its starting place
4. A push or a pull
5. Forces that result in no change in an object's motion
6. The force that resists motion
7. An object will remain at rest or move in a straight line with constant speed unless it is acted upon by a force. This is the definition of Newton's first law of ______________________________ .

Directions: *Circle the term in parentheses that makes the statement correct.*

8. (Velocity, Speed) is an object's displacement divided by time.
9. (Displacement, Acceleration) is the change in an object's velocity divided by the amount of time required for the change to occur.
10. A (force, motion) is a push or a pull.
11. When scientists need to measure force, they use the (newton, degree).
12. The first law of motion is sometimes called the law of (inertia, force).

Directed Reading for Content Mastery

Section 3 ▪ Newton's Second Law
Section 4 ▪ Newton's Third Law

Directions: *For each of the following, write the letter of the choice that best completes the sentence.*

______ 1. When you exert a force on an object it exerts ______ force back on you.
a. a stronger b. the same

______ 2. When volleyball players jump into the air, the primary force acting to make them land back on the ground is ______.
a. mass b. gravity

______ 3. Forces always act in ______.
a. pairs b. singles

______ 4. In a game of tug-o-war, the team that wins has exerted a greater ______ force.
a. unbalanced b. mass

______ 5. When you are pushing on a large door, ______ friction keeps you from sliding backwards.
a. unbalanced b. static

______ 6. ______ is determined by gravity.
a. weight b. mass

______ 7. A component of inertia is ______.
a. mass b. friction

______ 8. ______ friction causes a car tire to turn on the road.
a. Static b. Rolling

______ 9. ______ friction keeps an object from moving when a force is applied.
a. Static b. Sliding

______ 10. If the same force is applied to two different objects, the one with the ______ mass has a smaller acceleration.
a. larger b. smaller

Directed Reading for Content Mastery

Key Terms
Newton's Laws of Motion

Directions: *Complete the following sentences using the terms listed below.*

unbalanced	**force**	**first**
third	**friction**	**speed**

1. A ____________________ is a push or pull on an object.

2. When an object remains at rest or moves in a straight line with constant speed until it is acted upon by an unbalanced force, the ____________________ law of motion is demonstrated.

3. A(n) ____________________ force allows you to pick up your book bag.

4. The ____________________ law of motion says that for every action there is an equal but opposite reaction.

5. ____________________ is a way to measure the rate of motion.

6. If you are trying to ice skate and you fall, the ____________________ was too great between your skates and the ice.

Directions: *Unscramble the terms in italics to complete the sentences below. Write the terms on the lines provided.*

____________________ **7.** A car travels down the road at 30 miles per hour in a northwest direction which means it has *tylovcei.*

____________________ **8.** A student walks west from the school to the bus stop and has a *pmaseeilncdt* of 50 meters west.

____________________ **9.** The train slows down as it comes to the station producing *reectoclanai.*

____________________ **10.** When you roll a ball along the ground the ball is experiencing *gsiidln* friction.

____________________ **11.** Acceleration = force/mass is an example of Newton's *noceds* law of motion.

____________________ **12.** *tonoiM* is all around you.

____________________ **13.** *dalcenaB* forces will not change the motion of an object.

Nombre Fecha Clase

Lectura dirigida para Dominio del contenido

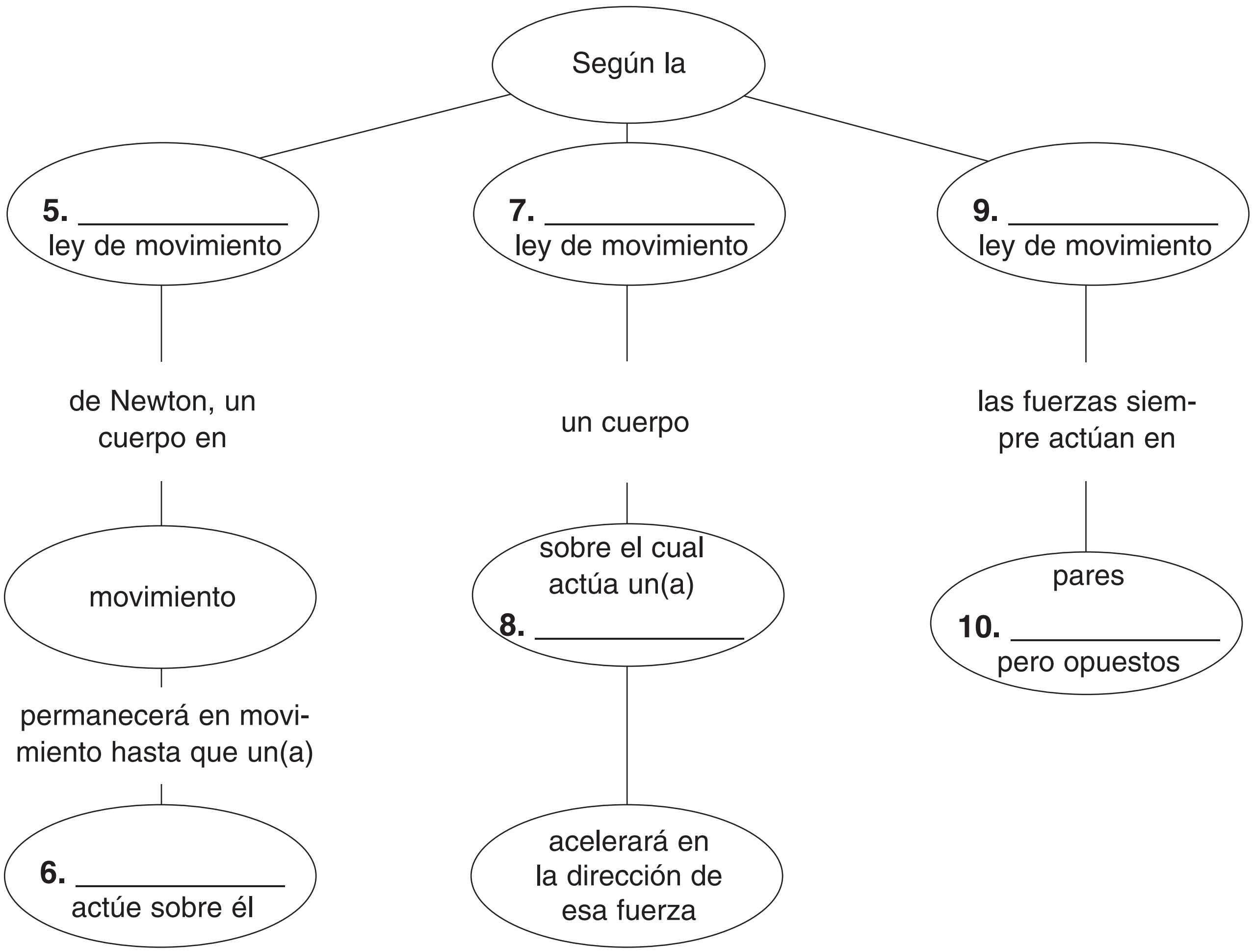
Sinopsis
Las leyes del movimiento de Newton

Instrucciones: *Completa las oraciones.*

1. Si caminas desde tu casa hasta la casa de tu amigo, la distancia y la dirección entre la casa de tu amigo y tu casa es ____________________.
2. La distancia viajada dividida entre el tiempo necesario para viajar tal distancia es el(la) ____________________.
3. El desplazamiento dividido entre el tiempo es ____________________.
4. Las fuerzas que se cancelan mutuamente son ____________________.

Instrucciones: *Completa el mapa de conceptos usando los siguientes términos. Algunos términos se usan más de una vez.*

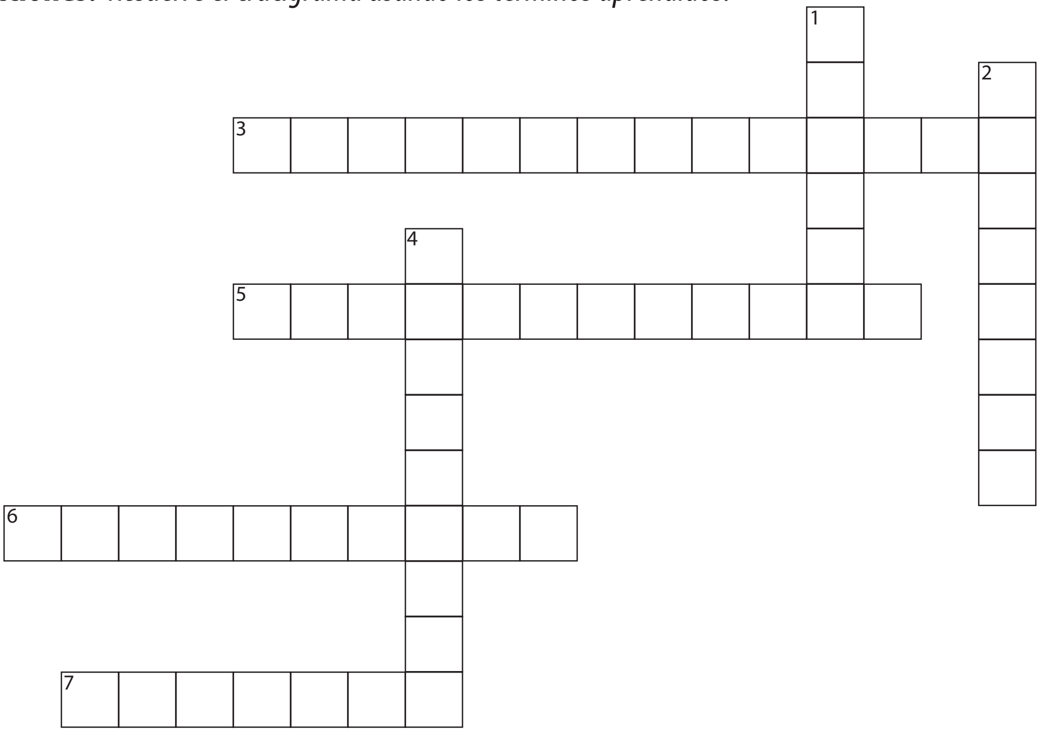
fuerza **segunda** **primera** **igual** **tercera**



Lectura dirigida para Dominio del contenido

Sección 1 ▪ El movimiento
Sección 2 ▪ La primera ley de Newton

Instrucciones: *Resuelve el crucigrama usando los términos aprendidos.*



Horizontales

3. La posición final a partir de la posición inicial.
5. Fuerzas que no resultan en un cambio en el movimiento de un cuerpo.
6. La primera ley de _______ de Newton establece que un cuerpo permanecerá en reposo o se moverá en línea recta con rapidez constante, a menos que una fuerza actúe sobre él.
7. Medida de la tendencia de un cuerpo a permanecer en reposo o continuar moviéndose con rapidez constante.

Verticales

1. Empujón o jalón.
2. Rapidez en un momento dado.
4. Medida del trayecto cubierto.

Instrucciones: *Encierra en un círculo el término en paréntesis que hace que cada oración sea verdadera.*

8. (Velocidad/Rapidez) es el desplazamiento de un cuerpo dividido entre tiempo.
9. El(La) (desplazamiento/aceleración) es el cambio en la velocidad de un cuerpo dividido entre la cantidad de tiempo que tomó el cambio.
10. Un(a) (fuerza/movimiento) es un empujón o un jalón.
11. Cuando los científicos necesitan medir la fuerza, usan el (newton/grado).
12. La primera ley del movimiento se conoce como la ley de la (inercia/fuerza).

Lectura dirigida para
Dominio del contenido

Sección 3 ▪ La segunda ley de Newton
Sección 4 ▪ La tercera ley de Newton

Instrucciones: *En cada una de las siguientes, escribe la letra del término que complete mejor cada oración.*

_______ **1.** Cuando ejerces fuerza sobre un cuerpo, el cuerpo ejerce una fuerza _______ contra ti.

a. más fuerte **b.** igual

_______ **2.** Cuando los jugadores de vólibol brincan, la fuerza primaria que actúa sobre ellos hasta que caen de nuevo al suelo es la _______.

a. masa **b.** gravedad

_______ **3.** Las fuerzas siempre actúan _______.

a. en pares **b.** por sí solas

_______ **4.** En un juego de guerra de la cuerda, el equipo que gana es el que ejerció la mayor fuerza _______.

a. desequilibrada **b.** de masa

_______ **5.** En un juego de guerra de la cuerda, el equipo que gana ejerció la fuerza _______ más grande.

a. desequilibrada **b.** estática

_______ **6.** La gravedad determina el(la) _______.

a. peso **b.** masa

_______ **7.** Una medida de la inercia es la _______.

a. masa **b.** fricción

_______ **8.** La fricción _______ hace que las llantas de un auto den vuelta al viajar.

a. estática **b.** de rodamiento

_______ **9.** La fricción _______ mantiene los cuerpos en su sitio cuando una fuerza actúa sobre ellos.

a. estática **b.** de deslizamiento

_______ **10.** Si se aplica la misma fuerza a dos cuerpos distintos, el que tiene la masa _______ tendrá la menor aceleración.

a. mayor **b.** menor

Lectura dirigida para Dominio del contenido

Términos claves Las leyes del movimiento de Newton

Instrucciones: *Completa las oraciones usando los siguientes términos.*

desequilibrada	**fuerza**	**primera**
tercera	**fricción**	**rapidez**

1. Un(a) ____________________ es un empujón o un jalón.

2. La ____________________ ley del movimiento se demuestra cuando un cuerpo permanece en reposo o se mueve en línea recta con rapidez constante hasta que una fuerza desequilibrada actúa sobre él.

3. Una fuerza ____________________ te permite levantar la mochila.

4. La ____________________ ley del movimiento establece que para cada acción existe una reacción igual, pero opuesta.

5. La tasa de movimiento se mide mediante el(la) ____________________.

6. Si tratas de patinar sobre el hielo y te caes, el(la) ____________________ entre tus patines y el hielo era demasiado fuerte.

Instrucciones: *Acomoda las letras de los términos en bastardilla para completar cada oración. Escribe los términos en las líneas de la izquierda.*

____________________ **7.** Un auto viaja por un camino a 30 millas por hora en dirección noreste, lo que significa que tiene *didvoleac.*

____________________ **8.** Un alumno camina hacia el oeste desde la escuela a la estación del autobús y tiene un *metoidpleazsnae* de 50 metros al oeste.

____________________ **9.** El tren viaja más lentamente al llegar a la estación produciendo *cónicaelare.*

____________________ **10.** Cuando haces rodar una pelota por el suelo, la pelota tiene fricción de *merdaoiton.*

____________________ **11.** Aceleración = fuerza/masa es un ejemplo de la *dugasen* ley de Newton.

____________________ **12.** Experimentas *neimotvomi* a todo tu alrededor.

____________________ **13.** Las fuerzas *sadarbiliuqe* no cambian el movimiento de un cuerpo.

Satisface las necesidades individuales

SECTION 1 Reinforcement

Motion

Directions: *Choose the term from Column II that best describes the examples in Column I. Some terms will not be used.*

Column I

_______ **1.** A dog is sitting beside the door of a house; five minutes later the dog is 10 m away from the door.

_______ **2.** A car travels on the freeway for 1.75 h with its cruise control set at 80 km/h.

_______ **3.** A wagon travels 4.6 km.

_______ **4.** A hiker walks north at 5 km/h.

_______ **5.** The speedometer of a car reads 55 km/h.

_______ **6.** A horse speeds up, runs around a track, then slows and comes to a stop.

_______ **7.** change in position

_______ **8.** A school office worker leaves the office, delivers messages around the school, and ends up back where she started.

Column II

a. motion

b. relative motion

c. distance

d. displacement

e. acceleration

f. instantaneous speed

g. speed

h. constant speed

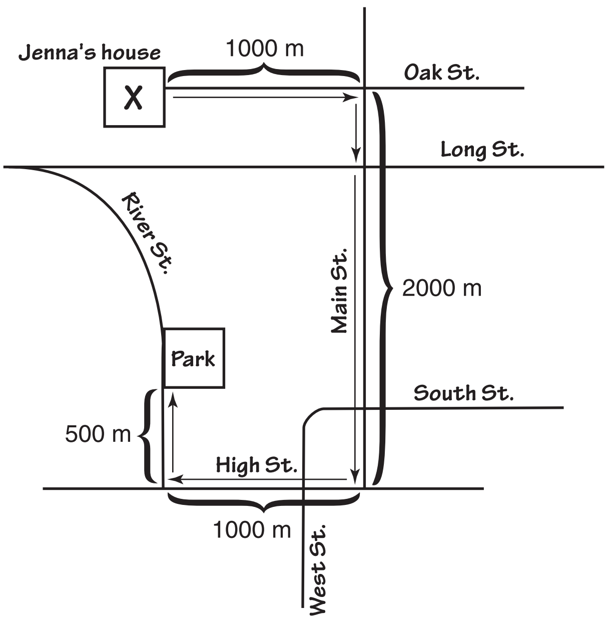
i. average speed

j. velocity

Meeting Individual Needs

Directions: *Use the map to answer questions 9 through 12.*

Jenna left home, walked around town, and ended at a park. The figure below shows the route of her walk.



9. What distance did Jenna walk?

____

10. What was Jenna's displacement?

____

11. If Jenna covered the entire distance in 5 hours, what was her average speed?

____

12. If Jenna started from rest and reached the corner of Oak St. and Main St. in 1.5 h and was walking with a velocity of 90 m/h, what was her acceleration between the start and corner A?

____

Name Date Class

SECTION 2 Reinforcement

Newton's First Law

Directions: *In question 1, below, a code letter has been substituted for each letter of the alphabet. To find what the sentence says, use the following key to decode it. In the key, the code letters are shown directly below the alphabet letter they stand for. Write the correct letter directly above each code letter, then read the sentence.*

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
X	M	J	W	T	A	O	U	R	V	G	Q	D	Z	B	Y	I	E	P	N	H	C	S	L	F	K

1. ______________________________

X MBWF ETDXRZP XN JBZPNXZN

____

CTGBJRNF HZGTPP XZ HZMXGXZJTW

____

ABEJT XJNP BZ RN

2. Which law of motion does the above sentence state?

____

____

Directions: *Answer the following questions on the lines provided.*

3. What is a force?

____

____

____

4. Is it possible for an object not to be in motion and still have forces acting on it? Explain.

____

____

____

____

5. What is inertia? How are mass and inertia related?

____

____

____

____

Meeting Individual Needs

Name Date Class

SECTION 3 Reinforcement

Newton's Second Law

Directions: *Circle the term in parentheses that best completes the statement.*

1. Gravity is a (force, mass, distance).
2. The friction involved in a wagon moving down a hill is (static, sliding, rolling) friction.
3. As the force acting on you increases, your acceleration (increases, decreases, remains the same).
4. The unit of force is the (meter, hertz, newton).
5. If you go to the moon, your mass (increases, decreases, remains the same).
6. As you glide across a frozen pond, (static, sliding, rolling) friction is acting on your skates.
7. If there is no change in force as you increase the mass a truck is carrying, its acceleration (increases, decreases, remains the same).
8. An ant falling from the roof of a house lands unharmed because of (gravity, static friction, air resistance).

Directions: *If the following statements are true, write* **true**. *If the statements are false, replace the term or phrase in italics to make the statement true.*

______________________ 9. If you go to the moon, your weight would *stay the same.*

______________________ 10. Given the same force, a baseball will accelerate *faster than* a tennis ball.

______________________ 11. The force always acting on everything on Earth is *gravity.*

______________________ 12. *Rolling friction* keeps a wagon from rolling until it is pushed.

Directions: *Solve the following problems in the spaces provided.*

13. A force of 40 N is exerted on a 10-kg box. What is the box's acceleration?

14. What unbalanced force is required to accelerate a 1,500 kg-race car at 3.0 m/s^2?

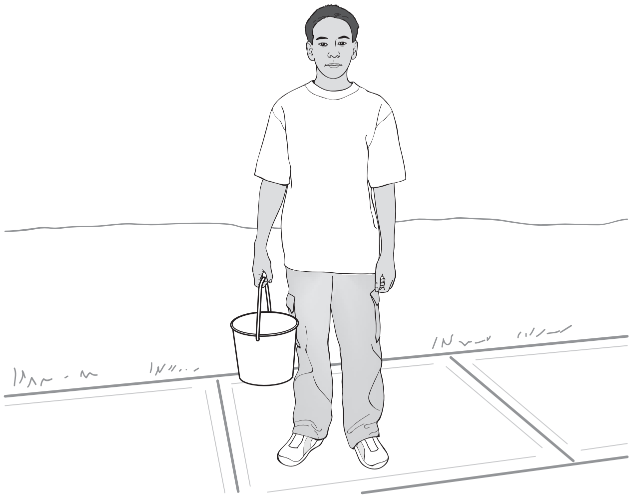
15. If a student has a mass of 90 kg, what is the student's weight?

Meeting Individual Needs

SECTION 4 Reinforcement

Newton's Third Law

Directions: *Study the drawing below of a boy holding a bucket and answer questions 1 through 4.*



1. Identify two pairs of action-reaction forces involving the bucket.

____

____

____

2. What are the balanced forces acting on the bucket?

____

____

____

3. What happens if the hand-on-bucket force increases? Explain.

____

____

4. What could you do to increase the Earth-on-bucket force?

____

____

Directions: *Find the mistakes in the statements below. Rewrite each statement correctly on the lines provided.*

5. An action-reaction force pair acts on the same body.

____

6. When action-reaction force pairs come into being, the action force is created first.

____

____

7. Action-reaction forces always act in the same direction.

____

8. Forces act in unequal but opposite pairs.

____

SECTION 1 Enrichment

Describing Motion

Describing motion is something we do in many different ways. Most people use terms like "slowed down" or "really fast." In science, other, more specific terms are used, for example, velocity and acceleration. Imagine a baseball announcer calling a game using scientific terms. You would probably understand what the players are doing, but you might have to explain it to someone not familiar with Newton's laws.

Directions: *In the following paragraph describing a home run, fill in the blanks using the correct scientific terms from the text. Remember that you are describing motion in scientific terms. Then answer the questions below.*

The player comes to bat. He hits the ball over the fence. Just before he starts to run, his **1.** ____________________ is zero. As he runs around first base and heads for second base his **2.** ____________________ and his **3.** ____________________ increase. As he continues to run around the bases, his speed is constant, but he is still **4.** ____________________ because he is constantly changing **5.** ____________________. As he approaches home plate, he slows slightly, thus **6.** ____________________ by changing his **7.** ____________________. Back at home plate, he has run the full **8.** ____________________ of the diamond, but his **9.** ____________________ is zero.

Directions: *Answer the questions on the lines provided.*

10. In what ways did the runner's velocity change?

____

____

____

11. How did you calculate the runner's displacement?

____

____

____

12. If the runner had only managed a base hit and stopped at first base would he still have been accelerating as he stopped? Explain your answer.

____

____

____

____

Meeting Individual Needs

SECTION 2 Enrichment

Crash-Test Dummies

More than one million people a year die in automobile crashes. Another 38 million are injured, with five million of those seriously or permanently hurt. While many people point to the lack of safety in cars, the real reason for the crashes is Newton's first law of motion. Remember that an object will remain at rest or continue moving in a straight line unless acted upon by a force. This universal law is also called the law of inertia.

Inertia

Inertia, the tendency of an object to remain at rest or continue moving with constant velocity, is dependent upon the mass of the object. This is exactly the kind of situation that exists when you are a passenger in a car. You are an object with inertia. When the car is hit, a force acts upon it. Depending on the size of the force and several other factors, you might or might not be hurt.

It's Only a Model

In an effort to make cars safer, automobile companies crash cars and study the effects of crashes on human bodies. Car makers want to build cars in which the crash force will not hurt the passengers or driver. It is not practical or legal to use real humans in these crashes, so a whole group of special human-like models called crash-test dummies have been created.

Studying Dummies

Crash-test dummies are basically human-like dolls that have sensors on them. In the laboratory, engineers and scientists stage and film car crashes. Then they look at the film and the dummies to determine the effects of the forces of inertia on the dummies. Most often they see evidence that the inertia of the dummy caused it to be damaged in the head and neck. These are the most dangerous places for a human to be hurt. By studying where the car is weakest and the most injury is caused to the dummy, engineers and scientists can build safer cars.

Building a Better Dummy

Every year the crash test dummies are replaced by increasingly human-like ones. They now slouch like a real human. They are more flexible like humans and they have more sensors on them to measure the effects and potential damage caused by the forces encountered in a crash. There are even child-sized dummies.

The hope is that the crash-test dummies will continue to provide additional life-saving information. Right now, you might owe some of your safety in an automobile to a crash-test dummy.

1. What is a crash-test dummy?

____

2. What feature does a crash-test dummy have to help scientists measure forces and their effects?

____

3. Why use crash-test dummies? _______________________________

____

4. In terms of forces and inertia, why do you think it is important to have different sizes of crash test dummies?

____

____

SECTION 3 Enrichment

Weight, Mass, and the Gold Rush

Gold has been precious to humans for thousands of years. A significant part of the history of the United States has to do with the discovery of gold. Many people grew rich from the huge amounts of gold discovered in California, Colorado, and Alaska. During the "gold rushes," people from all over the world hurried to these areas to try to make their fortunes. Many banks that exist today were founded on the huge income from gold miners.

Gold Weight

The banks that purchased gold from the miners were extremely careful about weighing the gold. Gold is, after all, a form of money. In fact, one banking company purchased extraordinary scales from a well known company called Howard and Davis in Boston, Massachusetts. These scales had jeweled movements that weighed so precisely that no one ever disputed them. A problem arose, however, when the gold was weighed in different places. Remember that Earth's mass produces the force of gravity. The closer an object is to the center of the Earth, the more it weighs. The farther it is from the center, the less it weighs.

Light Weights

When a bank in Denver, Colorado received a shipment of gold from San Francisco, California, it was always lighter than the paperwork said. And when a San Francisco bank received the gold from Colorado it was always heavy. The bank decided to send its scales along with its shipments, but the weights still varied.

How much does my gold weigh?

Only later was the problem understood. Because Denver was at a much higher altitude, the gold weighed less. The mass was still the same, but the weight was less. Eventually people realized that where the gold was weighed made a big difference in what the scales said. San Francisco was at sea level and Denver was at nearly 5,300 feet above sea level. This difference in altitude was enough to account for the difference in gold weight.

New Calculations

Now, mathematical calculations are used to make weights consistent. Newer scales and balances automatically correct for altitude and changes in the force of gravity. Should there be another gold rush, no longer would a miner at sea level make more money than a miner in the mountains for the same amount of gold.

1. What force affected the weight of gold between San Francisco and Denver?

2. What initial solution did the bankers come up with to try to make sure the gold was weighed correctly? Did it solve the problem?

3. How was this problem eventually solved?

4. Although the weight of the gold changed from one place to another, what stayed the same?

5. Do you think this means that two people with the same mass will weigh different amounts depending on where they live?

Meeting Individual Needs

SECTION 4 Enrichment

Motion in the Ocean

Nature contains many examples of Newton's laws of motion in action. Some interesting animals that demonstrate Newton's third law can be found under the sea.

Newton Underwater

The cephalopods are the group of animals that include the octopus, squid, nautilus, and a variety of other marine mollusks. They have tentacles and a well developed nervous system. Most important to Newton, however, would have been their water siphon. These animals have a special organ from which they can shoot water at a very high rate, which they use to propel themselves through the water.

Using a Siphon to Move

The nautilus is one example of an animal with this remarkable feature. The nautilus is a mollusk that lives in a coiled shell. The shell has compartments and makes an attractive display when cut in half. Mollusks produce a tissue called a mantle. The nautilus uses this mantle to form a tube that is on the side of its head. The tube can be filled with water. When the animal wants to move, it shoots water from the siphon.

Equal Force Pairs

The nautilus's propulsion system is a good example of an action producing a reaction. As the water is quickly shot out of the siphon, the animal moves in the opposite direction. The water moves in one direction and the nautilus, in an equal and opposite reaction, moves in the other.

An Equal and Opposite Reaction

Squid also use this type of jet propulsion. Some squid have been measured by scientists as fast as 24 to 80 km/h. Cephalopods do not move only in one direction, but can move the siphon to any position necessary. However, it must always be pointed to the opposite of the direction in which they need to move. Whichever way the water spurts, the animal will go in the opposite direction. This type of motion is one of the reasons cephalopods are so hard to catch. They are very fast animals. So, while a squid, nautilus, or octopus has never heard of Sir Isaac Newton, they are good examples of his third law in action.

1. How does a cephalopod demonstrate Newton's third law?

2. If a cephalopod wanted to turn right, which way would it point its siphon? Explain your answer.

3. If you were in the middle of a lake in a boat without an oar, do you think it would help you to have a bucket? Why or why not?

Note-taking Worksheet

Newton's Laws of Motion

Section 1 Motion

A. Motion is a change in ________________.

1. ________________—the entire path an object travels
2. The distance and direction between starting and stopping positions is ____________________.
3. ________________ motion—an object's position change is described in terms of a reference point

B. _____________—distance traveled divided by the time needed to travel the distance, or speed = $\frac{\text{distance}}{\text{time}}$

1. ______________________—speed is the same at any given moment in time
2. Speed at a particular instant in time is _____________________ speed.

C. ________________—displacement divided by time, or $v = \frac{\text{displacement}}{\text{time}}$

1. Formula calculates _______________ velocity.
2. Includes concept of _________________ as well as speed

D. Change in velocity divided by the time required for the change to occur is ____________________.

1. Acceleration occurs when an object __________________ as well as speeds up.
2. For an object traveling in a straight line, a change in _____________ can be used to calculate acceleration.
   a. Acceleration is final speed minus initial speed divided by _____________, or acceleration = $\frac{\text{(final speed – initial speed)}}{\text{time}}$.
   b. Initial speed is ____________ for objects at rest.
3. _______________ or changing direction is also acceleration.

Note-taking Worksheet (continued)

Section 2 Newton's First Law

A. Laws of ________________ are sets of rules first stated by Isaac Newton.

1. ________________—a push or pull with a size and direction
2. ________________ force involves objects touching each other.
3. ____________________ forces include gravity, magnetism, and electricity.
4. When scientists measure force, they use the ________________, abbreviated N.

B. ________________ **law of motion**—an object will remain at rest or move in a straight line with constant speed unless a force acts on it

1. ________________ measures an object's tendency to remain at rest or keep moving.
2. Inertia is related to ______________; objects with more mass have more inertia.

C. Adding forces—sometimes ___________________ one force acts on an object

1. __________________ **forces**—forces that are equal but in opposite directions, canceling each other
2. If one force is greater than another, a change in motion will result from the ____________________ **forces**.
3. An object acted on by an unbalanced force changes __________________.

Section 3 Newton's Second Law

A. **Second law of motion**—an object acted on by an unbalanced force will ____________________ in the direction of the force.

1. Acceleration equals force divided by mass, or $a = \frac{\text{force}}{\text{mass}}$.
2. Force is equal to the combination of all forces, or the _______________ force that acts on an object.

B. Second law can also be used to find _______________ if mass and acceleration are known.

1. Near Earth's surface, the force of gravity causes all objects to fall with the same ______________________—9.8 m/s^2.
   - **a.** For any object that is falling, the force of gravity ________________ mass times acceleration due to gravity, or $F = m \times (9.8 \text{ m/s}^2)$.
   - **b.** Because weight is the force of gravity on an object, an object's weight ________________ mass times acceleration due to gravity, or weight = $m \times (9.8 \text{ m/s}^2)$.

Note-taking Worksheet (continued)

2. Weight and mass are not the same thing.
    a. Weight changes when the acceleration due to ________________ changes.
    b. Mass remains the ______________ no matter what weight is.

C. __________________—a force that resists motion and is always present between two moving surfaces
1. ________________ friction—keeps a stationary object from moving on a surface when a force is applied to the object
2. _________________ friction—occurs when two surfaces slide past each other; slows down the moving object
3. _________________ friction—friction between a surface and a wheel turns the wheel.
4. Air ____________________—typical action of air molecules on a forward-moving object, slowing its motion

Section 4 Newton's Third Law

A. **Third law of motion**—________________ always act in equal but opposite pairs
1. When a force is exerted on an object, the object exerts the ______________ amount of force.
2. Third law of motion applies whether forces are contact or ___________________.

B. Things move because action and reaction forces work on ___________________ objects.
1. Friction is a factor in the third law.
2. Using the second law equation, the object with the larger mass has the smaller ______________________ if the same force is applied.
3. All objects in the universe exert a force on all others; however, differences in ______________ may make these forces unnoticeable.

C. The three laws of motion describe how any object moves when ________________ act on it.

Assessment

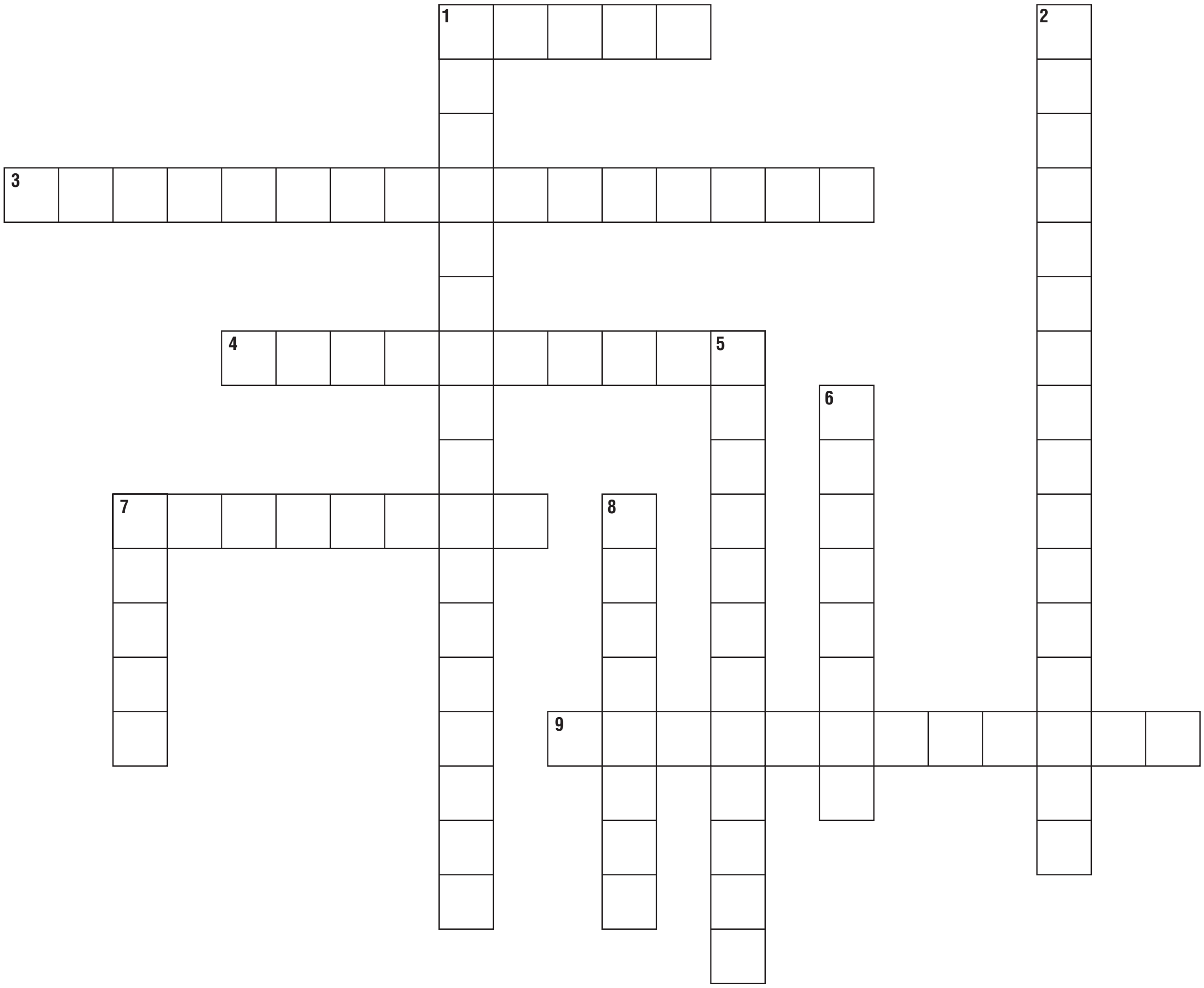
Name Date Class

Chapter Review

Newton's Laws of Motion

Part A. Vocabulary Review

Directions: *Use the clues below to complete the crossword puzzle.*



Across

1. Distance traveled divided by the time of travel
3. Objects remain at constant velocity unless an unbalanced force acts
4. Forces on an object that do not cancel out
7. Force that opposes motion
9. Rate of change of velocity

Down

1. Acceleration equals force divided by mass
2. For every action there is an equal and opposite reaction
5. Distance and direction between starting and ending positions
6. Forces on an object that cancel each other out
7. A push or a pull
8. Rate of change of displacement

Chapter Review (continued)

Part B. Concept Review

Directions: *Circle the term that best completes the sentence.*

1. If you drive from New York to San Francisco by way of Mt. Rushmore, Branson, MO, and Yellowstone National Park, your distance traveled is (greater than, less than, the same as) your displacement.
2. When your feet push on the floor so that you can walk across the room, you move but the floor doesn't. The force of the floor on your feet is (greater than, less than, the same as) the force of your feet on the floor.
3. Standing still in a windstorm is an example of (static, sliding, rolling) friction between your feet and the ground.
4. To push a box across the floor takes more force than to push the same box on wheels across the floor. This shows that rolling friction is (greater than, less than, equal to) sliding friction.
5. In order to keep a race car going around a circular track at constant speed, (no force, a balanced force, an unbalanced force) is needed.
6. A reaction force is created (before, after, at the same time as) its action force.

Directions: *Fill in the blank with the word that best completes the statement.*

7. A crumpled piece of paper falls to the ground faster than a smooth piece because of ____________________.
8. When you push a book across your desk, the force of your hand is ____________________ the force of static friction.
9. The force needed to accelerate a bowling ball to a given velocity is ____________________ the force needed to accelerate a soccer ball to the same velocity.

Directions: *Solve the following problems.*

10. A car travels 528 km in 6 hours. Find its average speed.

____

____

11. The maximum acceleration of a fist in a karate punch is 3800 m/s^2. The mass of the fist is 0.70 kg. If the fist hits a wooden block, what force does the wood place on the fist?

____

____

____

Assessment

Transparency Activities

SECTION 1 Section Focus Transparency Activity

Fast Circles

Race cars must meet certain specifications in order for the different racing teams to compete fairly with one another. After that, it's up to the driver to get the car around the track as quickly as possible.

1. Describe how a car's movements change as it goes from a straightaway, through a turn, and back to a straightaway.

2. How is a car's speed at a specific point on the track different from its average speed for the whole race?

3. During a race, a car might travel 200 miles. Where does it start and finish?

SECTION 2 Section Focus Transparency Activity

Outta My Way

If you are familiar with speed skating, you may have seen short-track competitions like the one below. In short-track racing, skaters compete on a track about the size of a hockey rink. In this short race, there are four skaters in each heat.

1. **What happens if a skater going in a straight line falls?**
2. **What happens if a skater falls in the middle of a turn?**
3. **Is it easier to walk on ice or asphalt? Why?**

Name Date Class

SECTION 3 Section Focus Transparency Activity

Rattling the Pins

Bowling has a long history—stone bowling balls and pins have been found in Egyptian tombs dating to 5200 B.C. Today, bowling balls are made of rubber, polyester, or urethane; the pins are made of wood with a plastic coating; and the lanes consist of a slick coating on top of wood.

1. What factors affect the way the pins fall?

2. Sometimes bowlers make the ball curve. Why do they do this?

SECTION 4 Section Focus Transparency Activity

Water Works

These firefighters are dousing a fire. Why does it take more than one person to aim the fire hose? The force of the water shooting out of the nozzle causes a reaction that can be pretty tough to control.

1. **What happens when you step from a canoe or a small boat onto a dock?**
2. **Why can a garden hose be controlled by one person while a fire hose needs several?**
3. **How might the action of a fire hose might be similar to a rocket engine?**

SECTION 1 Teaching Transparency Activity

Newton's Laws of Motion

Teaching Transparency Activity (continued)

1. Which of Newton's laws of motion is built around the idea that for every action there is an opposite and equal reaction?

2. What is the formula that can be used with Newton's second law of motion?

3. What is the force called when you kick a ball?

4. What unit do scientists use to measure force? What is the symbol for this unit?

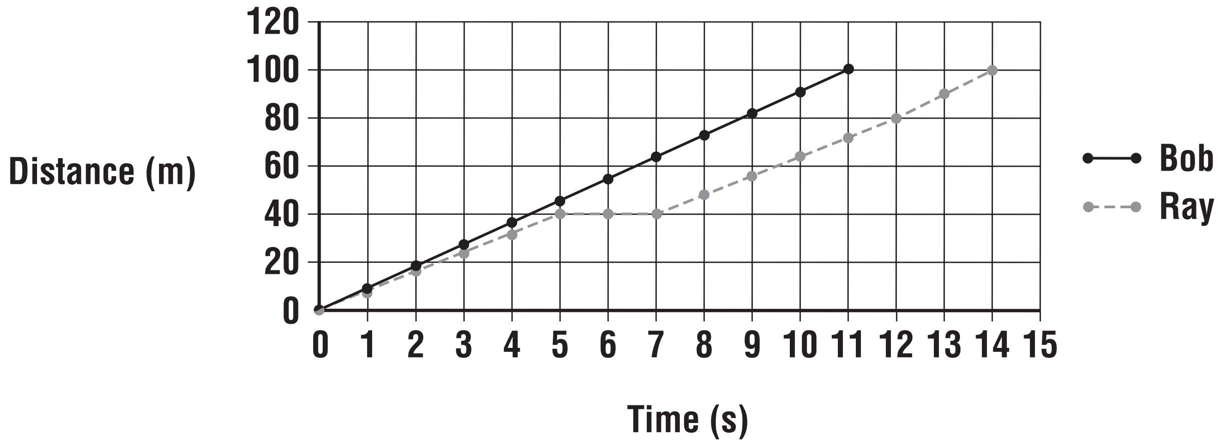
5. When a moving bus suddenly stops, what happens to the passengers? Which law of motion does this illustrate?

Name Date Class

Assessment Transparency Activity

Newton's Laws of Motion

Directions: *Carefully review the graph and answer the following questions.*



1. How long did it take Bob to run 100 meters?
- **A** 10 s
- **B** 11 s
- **C** 12 s
- **D** 14 s

2. After 9 seconds, about how much farther had Bob run than Ray?
- **F** 15 m
- **G** 20 m
- **H** 25 m
- **J** 30 m

3. According to the graph, about how many seconds would it take Bob to run 200 meters?
- **A** 14 s
- **B** 16.5 s
- **C** 22 s
- **D** 28 s

4. A reasonable hypothesis based on these data is that ____.
- **F** Ray probably tripped in the middle of the race
- **G** Ray runs faster than Bob
- **H** at one point in the race, Bob's speed was 0 m/s
- **J** after 5 seconds, Bob and Ray had run the same distance

Transparency Activities