Name: answer Key

Describing Motion Verbally with Distance and Displacement

Read from **Lesson 1** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/U1L1a.html
http://www.physicsclassroom.com/Class/1DKin/U1L1b.html
http://www.physicsclassroom.com/Class/1DKin/U1L1c.html

MOP Connection: Kinematic Concepts: sublevels 1 and 2

Motion can be described using words, diagrams, numerical information, equations, and graphs. Using words to describe the motion of objects involves an understanding of such concepts as position, displacement, distance, rate, speed, velocity, and acceleration.

Vectors vs. Scalars

1. Most of the quantities used to describe motion can be categorized as either vectors or scalars. *A vector is a quantity that is fully described by both magnitude and direction. A scalar is a quantity that is fully described by magnitude alone.* Categorize the following quantities by placing them under one of the two column headings.

displacement, distance, speed, velocity, acceleration

Scalars	Vectors
distance	displacement
speed	velocity
	acceleration

2. A quantity that is *ignorant of direction* is referred to as a SCALAR.
   a. scalar quantity   b. vector quantity

3. A quantity that is *conscious of direction* is referred to as a VECTOR.
   a. scalar quantity   b. vector quantity

Distance vs. Displacement

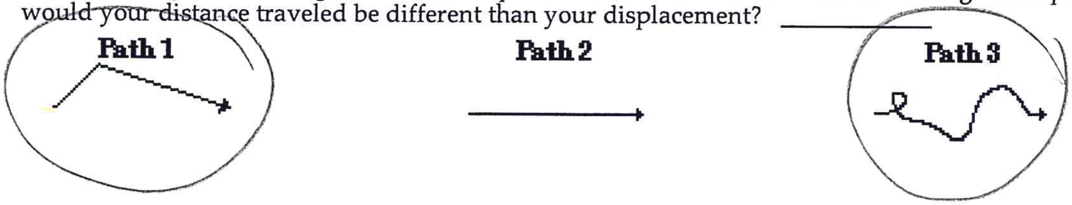
As an object moves, its location undergoes change. There are two quantities that are used to describe the changing location. One quantity - **distance** - accumulates the amount of total change of location over the course of a motion. Distance is the amount of ground that is covered. The second quantity - **displacement** - only concerns itself with the initial and final position of the object. Displacement is the overall change in position of the object from start to finish and does not concern itself with the accumulation of distance traveled during the path from start to finish.

4. True or False: An object can be moving for 10 seconds and still have zero displacement.
   a. True   b. False

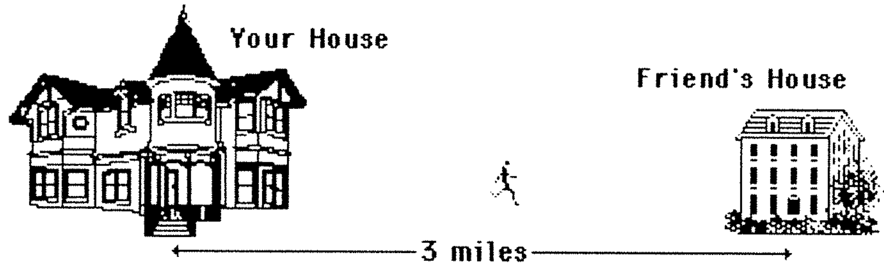
5. If the above statement is true, then describe an example of such a motion. If the above statement is false, then explain why it is false.

d_0 $d_0 = d_f$

6. Suppose that you run along three different paths from location A to location B. Along which path(s) would your distance traveled be different than your displacement? ______



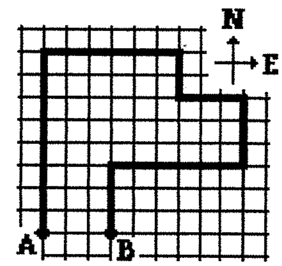
7. You run from your house to a friend's house that is 3 miles away. You then walk home.



a. What distance did you travel? 6 miles

b. What was the displacement for the entire trip? 0 miles

Observe the diagram below. A person starts at A, walks along the bold path and finishes at B. Each square is 1 km along its edge. Use the diagram in answering the next two questions.

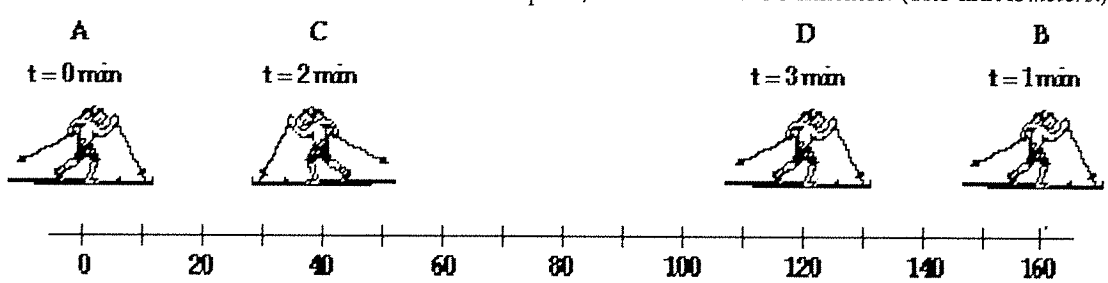


8. This person walks a distance of 32 km.

9. This person has a displacement of ________.

a. 0 km	b. 3 km	c. 3 km, E	d. 3 km, W
e. 5 km	f. 5 km, N	g. 5 km, S	h. 6 km
i. 6 km, E	j. 6 km, W	k. 31 km	l. 31 km, E
m. 31 km, W		n. None of these.	

10. A cross-country skier moves from location A to location B to location C to location D. Each *leg* of the back-and-forth motion takes 1 minute to complete; the total time is 3 minutes. (The unit is *meters*.)



a. What is the distance traveled by the skier during the three minutes of recreation?

160 + 120 + 80 = 360

b. What is the net displacement of the skier during the three minutes of recreation?

120 →

c. What is the displacement during the second minute (from 1 min. to 2 min.)?

120 ←

d. What is the displacement during the third minute (from 2 min. to 3 min.)?

80 →

Describing Motion Verbally with Speed and Velocity

Read from **Lesson 1** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/U1L1d.html

MOP Connection: Kinematic Concepts: sublevels 3 and 6

Review:

1. A SCALAR quantity is completely described by magnitude alone. A VECTOR quantity is completely described by a magnitude with a direction.
   a. scalar, vector b. vector, scalar

2. Speed is a __________ quantity and velocity is a __________ quantity.
   a. scalar, vector b. vector, scalar

Speed vs. Velocity

Speed and velocity are two quantities in Physics that seem at first glance to have the same meaning. While related, they have distinctly different definitions. Knowing their definitions is critical to understanding the difference between them.

Speed is a quantity that describes how fast or how slow an object is moving.

Velocity is a quantity that is defined as the rate at which an object's position changes.

3. Suppose you are considering three different paths (A, B and C) between the same two locations.

Path A **Path B** **Path C**

Along which path would you have to move with the greatest speed to arrive at the destination in the same amount of time? __________ Explain.

greater distance covered.

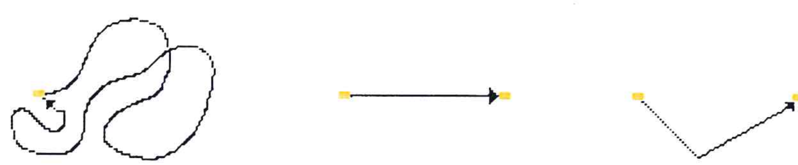
4. **True** or **False**: It is possible for an object to move for 10 seconds at a high speed and end up with an average velocity of zero.
   a. True b. False

5. If the above statement is true, then describe an example of such a motion. If the above statement is false, then explain why it is false.

velocity = Δposition $d_0 = d_f$

6. Suppose that you run for 10 seconds along three different paths.

Path A **Path B** **Path C**



Rank the three paths from the lowest average speed to the greatest average speed. B < C < A

Rank the three paths from the lowest average velocity to the greatest average velocity. __________

A < B = C

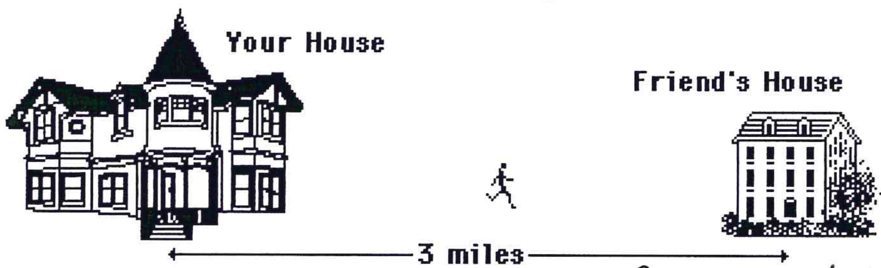
Calculating Average Speed and Average Velocity

The average speed of an object is the rate at which an object covers distance. The average velocity of an object is the rate at which an object changes its position. Thus,

$$\text{Ave. Speed} = \frac{\text{distance}}{\text{time}} \qquad \text{Ave. Velocity} = \frac{\text{displacement}}{\text{time}}$$

Speed, being a scalar, is dependent upon the scalar quantity distance. Velocity, being a vector, is dependent upon the vector quantity displacement.

7. You run from your house to a friend's house that is 3 miles away in 30 minutes. You then immediately walk home, taking 1 hour on your return trip.



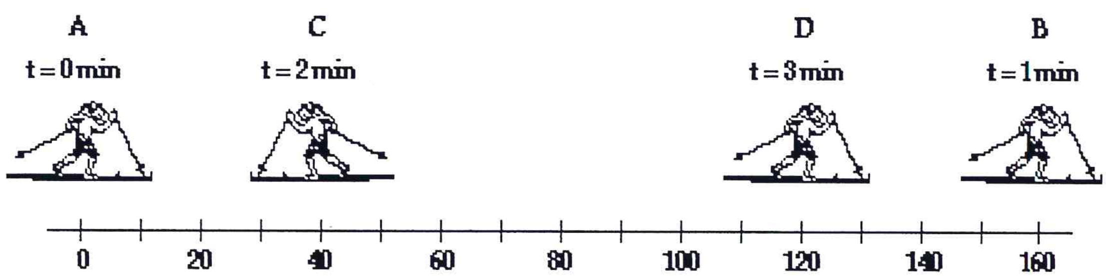
*note → not m/s because USA

$\boxed{4\ m/h}$

a. What was the average speed (in mi/hr) for the entire trip? 6miles / 1.5 hours

b. What was the average velocity (in mi/hr) for the entire trip? 0 m/h

8. A cross-country skier moves from location A to location B to location C to location D. Each *leg* of the back-and-forth motion takes 1 minute to complete; the total time is 3 minutes. The unit of length is meters.



Calculate the average speed (in m/min) and the average velocity (in m/min) of the skier during the three minutes of recreation. **PSYW**

Ave. Speed =

$$\frac{\Delta d}{\Delta t} = \frac{360\,mi}{3\,mins} = \boxed{120\,mi/min}$$

Ave. Velocity =

$$\frac{\Delta \vec{d}}{\Delta t} = \frac{120}{3} = \boxed{40\,mi/min}$$

Instantaneous Speed vs. Average Speed

The instantaneous speed of an object is the speed that an object has at any given instant. When an object moves, it doesn't always move at a steady pace. As a result, the instantaneous speed is changing. For an automobile, the instantaneous speed is the speedometer reading. The average speed is simply the average of all the speedometer readings taken at regular intervals of time. Of course, the easier way to determine the average speed is to simply do a distance/time ratio.

9. Consider the data at the right for the first 10 minutes of a teacher's trip along the expressway to school. Determine ...

   a. ... the average speed (in mi/min) for the 10 minutes of motion.

   $\frac{7.6}{10} = \boxed{0.76 \text{ mi/min}}$

   b. ... an estimate of the maximum speed (in mi/min) based on the given data.

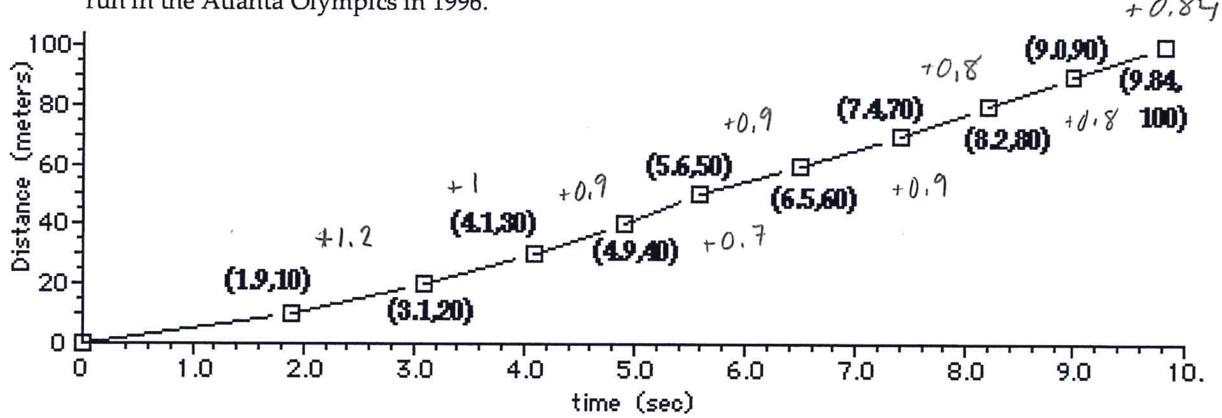
   from 8–9 mins

   $\frac{\Delta \vec{d}}{\Delta t} = \frac{6.4-5}{9-8} = \frac{1.4}{1} = \boxed{1.4 \text{ mi/min}}$

Time (min)	Pos'n (mi)
0	0
1	0.4
2	0.8
3	1.3
4	2.1
5	2.5
6	2.7
7	3.8
8	5.0
9	6.4
10	7.6

0.8
1.1
1.2
1.4
1.4

10. The graph below shows Donovan Bailey's split times for his 100-meter record breaking run in the Atlanta Olympics in 1996.



   a. At what point did he experience his greatest average speed for a 10 meter interval? Calculate this speed in m/s. **PSYW**

   between 1.9–3.1 secs $\frac{\Delta d}{\Delta t} = \frac{20-10}{3.1-1.9} = \frac{10}{1.2} = \boxed{8.\overline{3} \text{ m/s}}$

   b. What was his average speed (in m/s) for the overall race? **PSYW**

   $\frac{\Delta d}{\Delta t} = \frac{100-0}{9.84-0} = \frac{100}{9.84} = \boxed{10.16 \text{ m/s}}$

Problem-Solving:

11. Thirty years ago, police would check a highway for speeders by sending a helicopter up in the air and observing the time it would take for a car to travel between two wide lines placed 1/10th of a mile apart. On one occasion, a car was observed to take 7.2 seconds to travel this distance.
    a. How much time did it take the car to travel the distance in hours?

$$7.2\,s \times \left[\frac{1\,hr}{3600\,s}\right] = \boxed{0.002\,hrs}$$

    b. What is the speed of the car in miles per hour?

$$1/10^{th}\,mi = \frac{0.1\,m}{0.002\,h} = \boxed{50\,mi/h}$$

12. The fastest trains are magnetically levitated above the rails to avoid friction (and are therefore called MagLev trains…cool, huh?). The fastest trains travel about 155 miles in a half an hour. What is their average speed in miles/hour?

$$\frac{155\,mi}{0.5\,hr} = \boxed{310\,mi/hr}$$

13. In 1960, U.S. Air Force Captain Joseph Kittinger broke the records for the both the fastest and the longest sky dive…he fell an amazing 19.5 miles! (Cool facts: There is almost no air at that altitude, and he said that he almost didn't feel like he was falling because there was no whistling from the wind or movement of his clothing through the air. The temperature at that altitude was 36 degrees Fahrenheit *below* zero!) His average speed while falling was 254 miles/hour. How much time did the dive last?

$$\frac{254\,mi}{1\,hr} = \frac{19.5\,mi}{x} = 0.0768\,hrs \approx \boxed{0.08\,hrs}$$

14. A hummingbird averages a speed of about 28 miles/hour (Cool facts: They visit up to 1000 flowers per day, and reach maximum speed while diving … up to 100 miles/hour!). Ruby-throated hummingbirds take a 2000 mile journey when they migrate, including a non-stop trip across Gulf of Mexico in which they fly for 18 hours straight! How far is the trip across the Gulf of Mexico?

$$\frac{28\,mi}{hr} = \frac{x}{18\,hrs}$$

$$\boxed{504\,mi = x}$$

Acceleration

Read from **Lesson 1** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/U1L1e.html

MOP Connection: Kinematic Concepts: sublevels 4 and 7

Review:

The instantaneous velocity of an object is the $\vec{V}$ of the object with a given t.

The Concept of Acceleration

1. Accelerating objects are objects that are changing their velocity. Name the three controls on an automobile that cause it to accelerate.

   wheel, break, gas.

2. An object is accelerating if it is moving _____. Circle all that apply.
   a. with changing speed b. extremely fast c. with constant velocity
   d. in a circle e. downward f. none of these

   A + D

3. If an object is NOT accelerating, then one knows for sure that it is D.
   a. at rest b. moving with a constant speed
   c. slowing down d. maintaining a constant velocity

Acceleration as a Rate Quantity

Acceleration is the rate at which an object's velocity changes. The velocity of an object refers to how fast it moves and in what direction. The acceleration of an object refers to how fast an object changes its speed or its direction. Objects with a high acceleration are rapidly changing their speed or their direction. As a rate quantity, acceleration is expressed by the equation:

$$\text{acceleration} = \frac{\Delta \text{ Velocity}}{\text{time}} = \frac{v_{final} - v_{original}}{\text{time}}$$

4. An object with an acceleration of 10 m/s^2 will ____. Circle all that apply.
   a. move 10 meters in 1 second b. change its velocity by 10 m/s in 1 s
   c. move 100 meters in 10 seconds d. have a velocity of 100 m/s after 10 s

   B

5. Ima Speedin puts the pedal to the metal and increases her speed as follows: 0 mi/hr at 0 seconds; 10 mi/hr at 1 second; 20 mi/hr at 2 seconds; 30 mi/hr at 3 seconds; and 40 mi/hr at 4 seconds. What is the acceleration of Ima's car?

   $10 \text{ mi}/\text{hr} = 0.002\bar{7} \text{ mi}/\text{s}$ $\boxed{\vec{a} = +0.002\bar{7} \text{ mi}/\text{s}^2}$

6. Mr. Henderson's (imaginary) Porsche accelerates from 0 to 60 mi/hr in 4 seconds. Its acceleration is _____.
   a. 60 mi/hr b. 15 m/s/s c. 15 mi/hr/s d. -15 mi/hr/s e. none of these

7. A car speeds up from rest to +16 m/s in 4 s. Calculate the acceleration.

   $\vec{a} = \frac{\Delta v}{\Delta t} = \frac{16-0}{4-0} = 4 \text{ m/s}^2$

8. A car slows down from +32 m/s to +8 m/s in 4 s. Calculate the acceleration.

   $\vec{a} = \frac{\Delta v}{\Delta t} = \frac{8-32}{4-0} = \frac{-24}{4} = \boxed{-6 \text{ m/s}^2}$

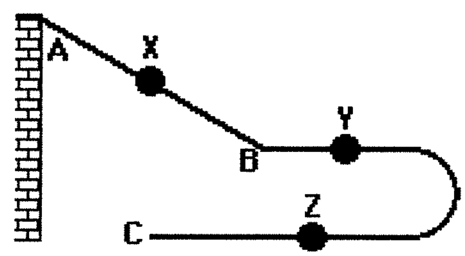
Acceleration as a Vector Quantity

Acceleration, like velocity, is a vector quantity. To fully describe the acceleration of an object, one must describe the direction of the acceleration vector. A **general rule of thumb** is that if an object is moving in a straight line and slowing down, then the direction of the acceleration is opposite the direction the object is moving. If the object is speeding up, the acceleration direction is the same as the direction of motion.

9. Read the following statements and indicate the direction (up, down, east, west, north or south) of the acceleration vector.

	Description of Motion	**Dir'n of Acceleration**
a.	A car is moving eastward along Lake Avenue and increasing its speed from 25 mph to 45 mph.	E
b.	A northbound car skids to a stop to avoid a reckless driver.	S
c.	An Olympic diver slows down after splashing into the water.	↑
d.	A southward-bound free quick delivered by the opposing team is slowed down and stopped by the goalie.	N
e.	A downward falling parachutist pulls the chord and rapidly slows down.	↑
f.	A rightward-moving Hot Wheels car slows to a stop.	L
g.	A falling bungee-jumper slows down as she nears the concrete sidewalk below.	↑

10. The diagram at the right portrays a Hot Wheels track designed for a phun physics lab. The car starts at point A, descends the hill (continually speeding up from A to B); after a short straight section of track, the car rounds the curve and finishes its *run* at point C. The car continuously slows down from point B to point C. Use this information to complete the following table.



Point	Direction of Velocity of Vector	Direction of Acceleration Vector
X	↘ Reason: gravity	↘ Reason: speeding up
Y	→ Reason: track	← Reason: slowing
Z	← Reason: track	→ Reason: slowing

Describing Motion with Diagrams

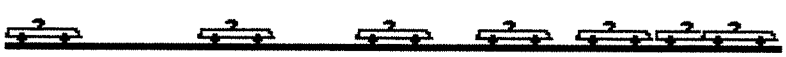
Read from **Lesson 2** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/U1L2a.html
http://www.physicsclassroom.com/Class/1DKin/U1L2b.html
http://www.physicsclassroom.com/Class/1DKin/U1L2c.html

MOP Connection: Kinematic Concepts: sublevel 5

Motion can be described using words, diagrams, numerical information, equations, and graphs. Using diagrams to describe the motion of objects involves depicting the location or position of an object at regular time intervals.

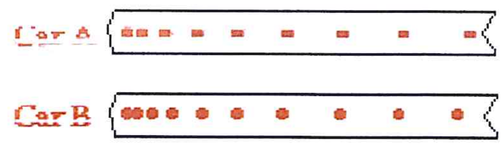
1. Motion diagrams for an amusement park ride are shown. The diagrams indicate the positions of the car at regular time intervals. For each of these diagrams, indicate whether the car is accelerating or moving with constant velocity. If accelerating, indicate the direction (right or left) of acceleration. Support your answer with reasoning.

	Acceleration: Y/N	Acceleration: Dir'n
a.  Reason: $\Delta d / \Delta t$ = constant	N	
b.  Reason: speeding up	Y	→
c.  Reason: $\Delta d / \Delta t$ = constant	N	
d.  Reason: speeding up	Y	→
e.  Reason: slowing down.	Y	←

2. Suppose that in diagram D (above) the cars were moving leftward (and traveling backwards). What would be the direction of the acceleration? ____________ Explain your answer fully.

→ slowing down, so $\vec{a}$ direction opposes direction of motion

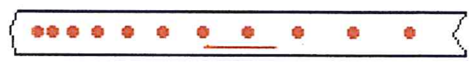
3. Based on the oil drop pattern for Car A and Car B, which of the following statements are true? Circle all that apply.



   a. Both cars have a constant velocity.
   b. Both cars have an accelerated motion.
   c. Car A is accelerating; Car B is not.
   d. Car B is accelerating; Car A is not.
   e. Car A has a greater acceleration than Car B.
   f. Car B has a greater acceleration than Car A.

   B + E

4. An object is moving from right to left. It's motion is represented by the oil drop diagram below. This object has a _______ velocity and a _______ acceleration.



   a. rightward, rightward
   b. rightward, leftward
   c. leftward, rightward
   d. leftward, leftward
   e. rightward, zero
   f. leftward, zero

   C

5. Renatta Oyle's car has an oil leak and leaves a trace of oil drops on the streets as she drives through Glenview. A study of Glenview's streets reveals the following traces. Match the trace with the verbal descriptions given below. For each match, verify your reasoning.

Diagram A: 

Diagram B:

Diagram C: 

	Verbal Description	Diagram
i.	Renatta was driving with a slow constant speed, decelerated to rest, remained at rest for 30 s, and then drove very slowly at a constant speed. Reasoning: spacing is even + slow	C
ii.	Renatta rapidly decelerated from a high speed to a rest position, and then slowly accelerated to a moderate speed. Reasoning: stop	A
iii.	Renatta was driving at a moderate speed and slowly accelerated. Reasoning: medium spacing	B