BC SCIENCE 10

Provincial Exam Study Guide
Unit 3: Motion

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BC Science 10 Provincial Exam Study Guide

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Part A Strategies for Success

Study Tips for Provincial Exam Preparation

Introduction

This guide is designed to help you study for the BC Science 10 provincial exam. Completing all the questions in this Study Guide will not guarantee that you will pass the exam, but it will help prepare you for success.

Each unit in this Study Guide matches up to a unit in your *BC Science 10* student book. Each Study Guide unit begins with a checklist of what you should be able to do by the end of that unit. You can use this checklist to help you figure out which concepts you already know and which concepts you need to study further. Each Study Guide unit ends with a checklist of Processes of Science Vocabulary Terms that you should know and a Glossary of terms from the unit that you should understand.

Each section in the Study Guide has the following features.

- Summary of Key Points—you must know each of these key points for the exam
- Study Notes—these are the key points expanded to include details that may be on the exam
- Quick Check—these are questions to check your understanding of the Study Notes. If you cannot answer Quick Check questions, review the material in your student book or talk to your teacher.
- Sample Exam Questions Explained—this feature explains in detail the right and wrong answers for questions that are similar in style to the questions that will be on the provincial exam. The feature also describes why each question was asked and where you can get additional help if you did not understand the question. One strategy to help you study is to cover up the right-hand column in the question and try to answer the question first. Then, uncover the column to check your answer or to figure out why an answer is wrong. Figuring out why you got an answer wrong can help you to learn the concept.
- Practice Questions—these are questions that are similar in style to the questions that will be on the provincial exam. There are 10 Practice Questions at the end of each section.

Support for Studying

When you study for the provincial exam, you should have the following materials. If you are missing any of the items below, please see your teacher.

- ***BC Science 10* student book** Your student book covers the same curriculum that the provincial exam was developed for. It is an excellent source of information for studying.
- **Your notes** Your teacher has worked the whole semester or school year with you to help you develop the right knowledge, skills, and attitudes. A key part of this work is the notes you have created. Remember to review these notes while you study.
- **BC Science 10 Provincial Exam Data Pages** It is very important that you understand the parts of the Provincial Exam Data Pages and how to use them. Your teacher can answer your questions about these pages.
- **BC Science 10 Provincial Exam Vocabulary List** You should know the meaning of each of these terms. If you are unsure of any of the terms, check the Glossary at the end of each Study Guide unit or at the back of your student book.
- **The BC Science 10 website** You can find practice questions and web links that will help you study the material you have covered in Science 10 this year. Visit www.bcscience10.ca.

Getting Help

When you study for a year-end test like the provincial exam, it is not uncommon to get stuck on concepts or have questions on material you have previously covered in class. If you are unsure about a concept or something covered in class, check with a classmate first. If both of you cannot figure out the answer, visit your teacher together.

Tips from Experts

Study experts have a common list of hints they provide to people of all ages. Research has shown that these tips help you study.

- Have a **positive attitude.**
- **Be motivated** and take responsibility for your learning.
- **Attend class** so you do not miss key points about what you are learning. Your friend's notes are not a replacement for being present in class and learning the concepts while they are being taught.
- **Study regularly** to help you identify areas where you need extra help.
- **Get help** when you need it, and do not be afraid to ask questions. There are no bad questions when it comes to figuring something out.
- **Be a good test taker.** Have a good sleep the night before the test and be sure to eat a nutritious breakfast the day of the test. During the test, read each question carefully before selecting your answer.

Here is a list of common hints that science teachers in British Columbia have shared with their students.

- Know how to use your Data Pages.
- Practise reading graphs.
- Practise interpreting illustrations.
- Do not spend extra time studying what you already know.
- When you are writing the exam, read the question first, then read the possible answers. If you do not know the answer, then look at the picture (if there is a picture).
- Take your time when you write the exam. Answer the questions you know first, and then go back to questions that you are not sure of.

Part B Unit Study Notes and Exam Questions

Unit 3 Motion

By the end of this unit, you should be able to:

1. Explain the relationship of displacement and time interval to velocity for objects in uniform motion
   This includes being able to:
   - ☐ define displacement (change in position, Δd), time interval (Δt), and velocity ($\vec{v}_{av}$)
   - ☐ analyze graphically the relationship between displacement and time interval for an object traveling in uniform motion
   - ☐ use the formula $\vec{v}_{av} = \Delta d / \Delta t$ to calculate the average velocity ($\vec{v}_{av}$), displacement (change in position, Δd), and time interval (Δt) for an object in uniform motion, given appropriate data
   - ☐ design and conduct one or more experiments to determine the velocity of an object in uniform motion (e.g., using carts, balls, skateboards, bicycles, canoes in still water)
2. Demonstrate the relationship between velocity, time interval, and acceleration
   This includes being able to:
   - ☐ define acceleration (positive, negative, and zero)
   - ☐ give examples of positive, negative, and zero acceleration, including
     - – falling objects
     - – accelerating from rest
     - – slowing down or stopping
     - – uniform motion

By the end of this unit, you should understand the following key ideas:

1. Average velocity is the rate of change in position.
2. Acceleration is the rate of change in velocity.

To help you study you should have the following:

- *BC Science 10* student book pages 338 to 417. Note the practice exam questions on pages 416 and 417.
- BC Science 10 Provincial Exam Data Pages page 4.
- BC Science 10 Provincial Exam Vocabulary List, page 2.
- Access to www.bcscience10.ca.

Chapter 8 Average velocity is the rate of change in position.

8.1 The Language of Motion

I. Summary of Key Points

- A vector quantity has both a magnitude and a direction.
- Position and displacement are vector quantities.
- A scalar quantity has magnitude only.
- Distance and time are scalar quantities.
- The magnitude of an object's displacement will be the same as the distance an object travels only if it travels in a straight line in one direction.
- An object in uniform motion travels equal displacements in equal time intervals.
- Uniform motion is represented as a straight line on a position-time graph.

II. Study Notes

Direction Makes a Difference and **Representing Vectors**

1. **Magnitude** refers to the size of a measurement or the amount you are counting.
2. Quantities that describe magnitude but do not include direction are called scalar quantities.
   Example: 25 s
3. Quantities that describe magnitude and also include direction are called vector quantities.
   Example: 5 km N
4. Vector abbreviations are sometimes written in bolded italics with an arrow above them, such as $\vec{\boldsymbol{v}}$ for velocity and $\vec{\boldsymbol{d}}$ for position.
5. When a direction is written in a vector description, it is usually abbreviated and put into square brackets, such as 10 km [E] for 10 km east.

Quick Check

1. Identify each of the following quantities as either vector or scalar.

   (a) 10 kg ______________________

   (b) 20 m [S] ______________________

   (c) 5 hours driving in a car ______________________

   (d) swimming for 100 m [N] ______________________

   (e) 15°C ______________________

Time Interval and Position

1. Time (t) is a concept that describes when an event occurs.
2. Initial time (t_i) is when the event began.
   Final time (t_f) is when the event finished.
3. **Time interval** is the difference between the final and initial times.
   - Time interval is calculated by: $\Delta t = t_f - t_i$

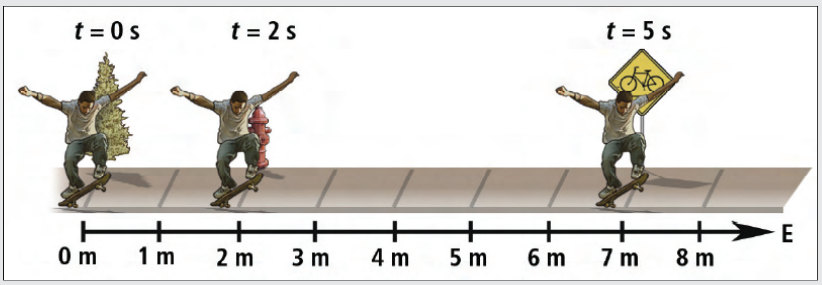
Distance and Position

1. **Distance** (*d*) is a scalar quantity that describes the length of a path between two points or locations.
   Example: A person ran a distance of 400 m.
2. **Position** (*d*) is a vector quantity that describes a specific point relative to a reference point.
   Example: The school is 3.0 km east of my house.
3. The SI unit for both distance and position is metres, m.

Displacement and Distance

1. **Displacement** describes the straight-line distance and direction from one point to another.
   - Displacement describes how much an object's position has changed.
   - Displacement is equal to the final position minus the initial position.
2. The SI unit for displacement is metres, m.

Quick Check



Use the diagram above to answer the following questions.

1. (a) How long did it take the skateboarder to travel 7.0 m?

   ____

   (b) If the skateboarder started at 0 m and stopped at 2.0 m, what would be t_f?

   ____

2. Write three sentences that illustrate the difference between distance, position, and displacement.

   (a) Distance ______________________________

   ____

   (b) Position ______________________________

   ____

   (c) Displacement ______________________________

   ____

Direction and Signs

1. To indicate an opposite direction for a vector quantity, an opposite sign is used. The common sign conventions are shown in Figure 8.1.

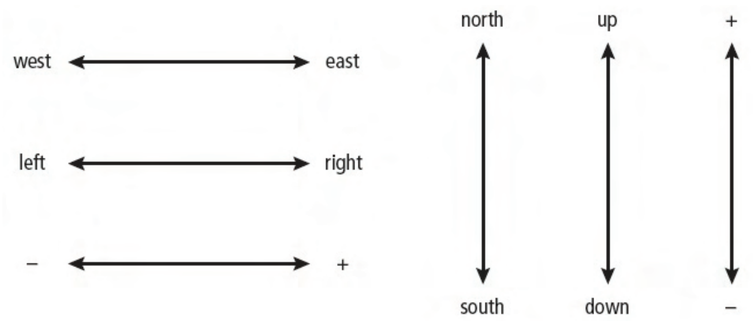


FIGURE 8.1 North, east, up, and right are called positive (+). South, west, down, and left are called negative (–).

Quick Check

1. Write the opposite direction for the following vector quantities.

   (a) 10 m [N] ______________________

   (b) 5.0 m/s up ______________________

   (c) –20 cm/h ______________________

   (d) 50 km/h [W] ______________________

   (e) –15 km ______________________

Uniform Motion and **Graphing Uniform Motion**

1. All objects in **uniform motion** meet the following conditions.
   - Objects in uniform motion travel equal displacements in equal time intervals.
   - Objects in uniform motion do not speed up, slow down, or change direction.
2. Motion of an object can be analyzed by drawing a position-time graph (Figure 8.2).
   - A position-time graph plots position data on the vertical axis (y-axis) and time data on the horizontal axis (x-axis).
3. A best-fit line is a smooth curve or straight line that most closely fits the general shape outlined by the points.
4. Uniform motion is represented by a straight line on a position-time graph. The straight line passes through all the plotted points.

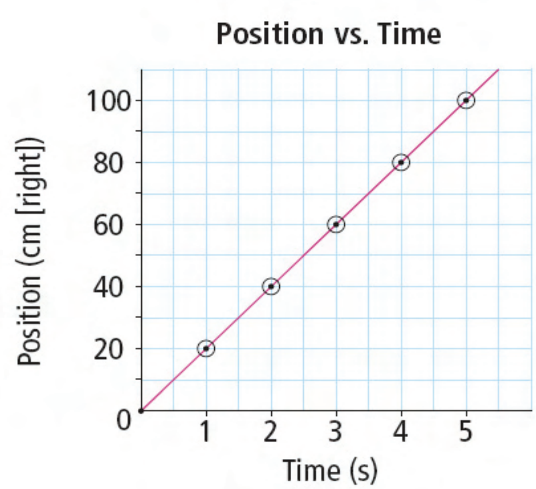
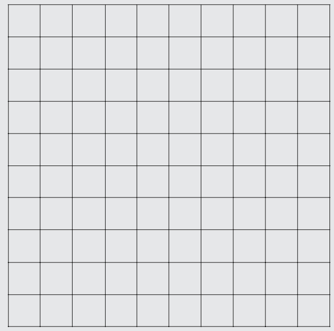


FIGURE 8.2 Position-time graph

Quick Check

1. Graph the following data of an object in motion and answer the questions below.

Time (s)	Position (m)
0	5
1	9
2	14
3	22
4	26



2. (a) Is the object in uniform motion? _______

   (b) Support your answer.

____

____

Slope

1. The **slope** of a graph refers to whether a line is horizontal or goes up or down at an angle.

2. Positive slope (Figure 8.3)
   Line slants up to the right.
   Indicates motion in the direction of the positive *y*-axis

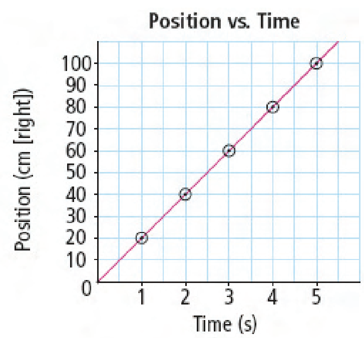


FIGURE 8.3 Positive slope

3. Zero slope (Figure 8.4)
   Line is horizontal.
   Indicates that the object is stationary

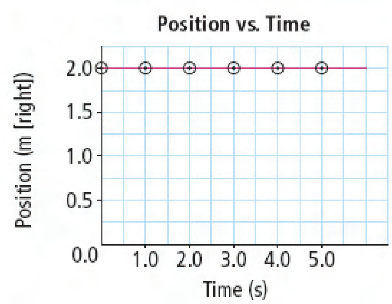


FIGURE 8.4 Zero slope

4. Negative slope (Figure 8.5)
   Line slants down to the right.
   Indicates motion in the direction of the negative *y*-axis

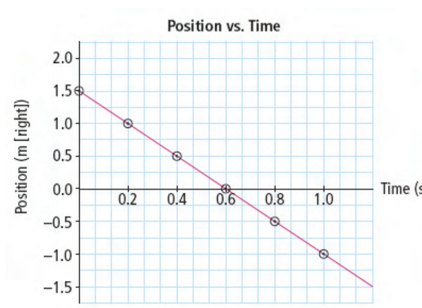


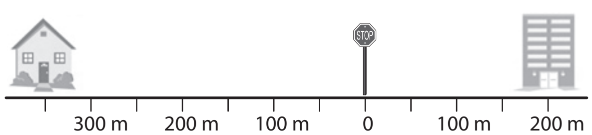
FIGURE 8.5 Negative slope

Quick Check

Create a graph to represent the following motion.

1. A person cycles 10 km in 30 min and then stops for 15 min. Then, the cyclist returns home in 15 min.

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
What is the distance from the house to the school in the diagram below? 	
A. 550 m	A. This answer is correct.
B. 150 m	B. Subtracting the two distance quantities does not give you the distance between the two places.
C. 550 m [E]	C. Distance is a scalar quantity, and direction is not needed.
D. 150 m [W]	D. To get the distance between the two objects. you add both distances, not subtract. Distance is a scalar quantity, so direction is not required.

➜ Why was this question asked?

This question was asked to determine if you can demonstrate an understanding of the difference between displacement and distance. Displacement is a vector quantity and direction is required. Distance is a scalar quantity and direction is not required.

➜ Where can I get extra practice on this type of question?

- Use pages 344 to 361 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
A delivery truck travels directly north for 15 min. At the end of the trip the driver notes she has travelled 20 km. What is the average velocity of the truck during the trip?	
A. 1.3 km/h	A. The time used in the calculation is not 15 min but 0.25 h. The units used in the calculation must match the answer.
B. 80 km/h	B. The calculation of velocity is correct, but a direction must be included for this vector quantity.
C. 1.3 km/h [N]	C. The direction is correct and required for average velocity, but the time used in the calculation is not 15 min but 0.25 h. The units used in the calculation must match the answer.
D. 80 km/h [N]	D. This answer is correct.

➜ Why was this question asked?

This question was asked to determine if you understand how to correctly calculate average velocity. Remember that velocity is a vector quantity and a direction is required.

➜ Where can I get extra practice on this type of question?

- Use pages 344 to 361 in *BC Science 10.*
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

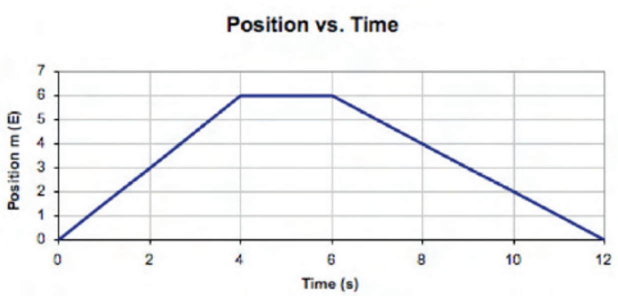
Section 8.1

Average velocity is the rate of change in position: The Language of Motion

Circle the letter of the best answer.

1. What term describes quantities that have a magnitude but no directional component?
   A. amplitude
   B. velocity
   C. vectors
   D. scalars

Use the graph below to answer the following two questions 2 and 3.



2. What is the total displacement of this object?
   A. 0 m
   B. 6.0 m [E]
   C. 6.0 m [W]
   D. 12 m

3. What does the horizontal section of the graph between time 4 s and 6 s indicate about the object?
   A. The object is at rest.
   B. The object has turned south.
   C. The object has slowed down.
   D. The object is moving over a plateau on a hilltop.

4. If a rolling cart moves with uniform motion at a rate of 2 m/s in the forward direction, what will its displacement be after 5 s?
   A. 0.4 m
   B. 2.0 m
   C. 10 m
   D. 100 m

5. A golf ball is hit from the right side of a hole (+) at a constant speed and travels toward the hole. If you were to make a position vs. time graph representing the ball's journey, would the slope of the graph be positive, negative, or zero?
   A. both negative and positive slope
   B. negative slope
   C. positive slope
   D. zero slope

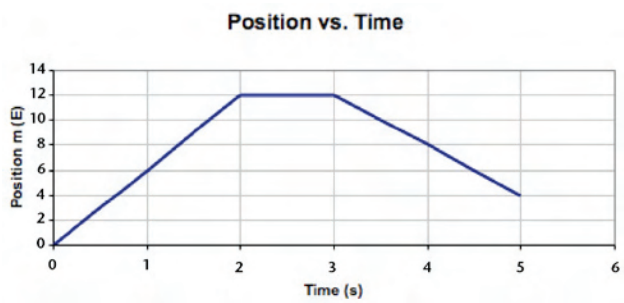
Use the following data to answer question 6.

Time (s)	Position (m)
0	0
1	5
2	10
3	15

6. A cyclist coasts forward on a flat, obstacle-free road. What was the total displacement of the cyclist?
   A. 0 m
   B. 5.0 m
   C. 10 m
   D. 15 m

7. If you were to create a position-time graph for someone who is standing still, what kind of slope would the graph have?
   A. zero slope
   B. positive slope
   C. negative slope
   D. both negative and positive slope

Use the graph below to answer question 8.



8. What is the total displacement of the object based on the graph above?
   A. 4.0 m
   B. 12.0 m
   C. 20 m
   D. −4.0 m

9. What is the definition of "displacement"?
   A. a quantity that has only a magnitude
   B. a scalar quantity that describes the length of a path between two points
   C. a vector quantity that describes the straight-line distance between two points
   D. the distance an object travels during a given time interval divided by the time interval

10. What symbol is used to represent change in a quantity?
    A. $\vec{d}$
    B. Δ
    C. γ
    D. d

8.2 Average Velocity

I. Summary of Key Points

- Average velocity is the rate of change in position.
- Speed is the magnitude of the velocity.
- The slope of the best-fit line on a position-time graph is average velocity.
- The relationship between average velocity, displacement, and time interval is given by
  $\vec{v}_{av} = \Delta\vec{d}/\Delta t$

II. Study Notes

Speed and Velocity

1. **Speed** (v) is the distance an object travels during a time interval divided by the time interval.
   - Speed is a scalar quantity.
   - The SI unit for speed is metres per second (m/s).
2. **Velocity** ($\vec{v}$) is the displacement of an object during a time interval divided by the time interval.
   - Velocity describes how fast an object's position is changing.
   - Velocity is a vector quantity and therefore must include direction.
   - The SI unit for velocity is metres per second (m/s).
3. The direction of the velocity is the same as the direction of the displacement.
4. Objects travelling the same speed can have different velocities.
   - If they are travelling in opposite directions, one object is given a positive velocity and the other is given a negative velocity.

Quick Check

1. Fill in the blanks.
   (a) Velocity is the ____ of an object during a time interval divided by the time interval.
   (b) Speed is the ____ an object travels during a time interval divided by the time interval.

Calculating the Slope of the Position-Time Graph

1. The slope of a graph represents $\frac{\text{rise}}{\text{run}}$, which is the change in the y-axis divided by the change in the x-axis.
2. On a position-time graph, the slope is the change in position ($\Delta\vec{d}$) divided by the change in time (Δt).
3. The steeper the slope, the greater the change in displacement during the same time interval.

Average Velocity

1. The slope of a position-time graph is the object's average velocity.
   - Average velocity is the rate of change in position for a time interval.
2. The symbol for average velocity is $\vec{v}_{av}$.
3. If "forward" is given a positive direction on a position-time graph:
   - A positive slope means that the object's average velocity is forward.
   - A negative slope means that the object's average velocity is backward.
   - Zero slope means the object's average velocity is zero.

Quick Check

Use the position-time graph below to answer question 1.

1. (a) Which jogger was travelling faster? ____________

   (b) How do you know? ____

   ____

Use the position-time graph below to answer question 2.

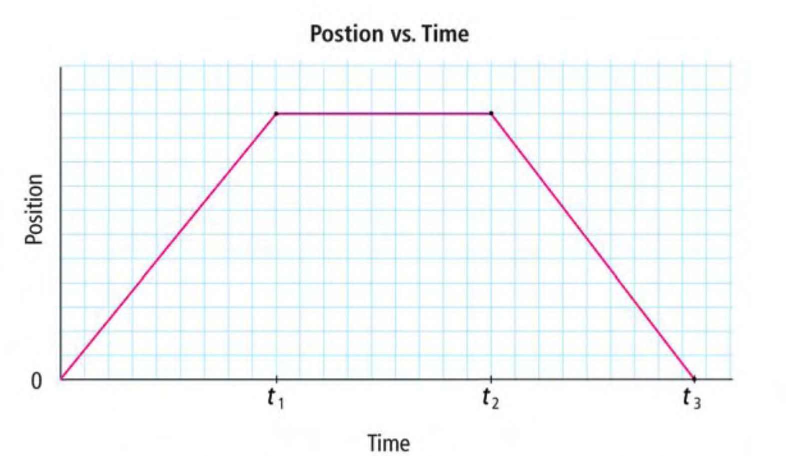


Figure 8.19 The slope of a position-time graph represents the object's average velocity.

2. (a) During which time interval was the object remaining stationary?

   ____

   (b) During which time interval was the object moving away from its origin?

   ____

   (c) During which time interval was the object returning to its origin?

   ____

Calculating Average Velocity

1. The relationship between average velocity, displacement, and time is given by:
   $\vec{v}_{av} = \Delta\vec{d}/\Delta t$

Calculating Displacement

1. The relationship between displacement, average velocity, and time is given by:
   $\Delta\vec{d} = (\vec{v}_{av})(\Delta t)$

Calculating Time

1. The relationship between time, average velocity, and displacement is given by:
   $\Delta t = \Delta\vec{d}/\vec{v}_{av}$

Quick Check

1. A boat travels 280 m [E] in a time of 120 s. What is the boat's average velocity?

2. What is the displacement of a bicycle that travels 8.0 m/s [N] for 15 s?

3. A fruit fly leaves a windowsill and flies over to a banana that is 2.0 m west of its starting point. The fly travels in a curved path and actually travels a total of 20 m during its flight to the banana. The flight lasts for a total of 4.0 s.
   (a) What is the fly's average speed?

   (b) What is the fly's average velocity?

4. How long would it take a cat walking north at 0.80 m/s to travel 12 m north?

Converting km/h into m/s

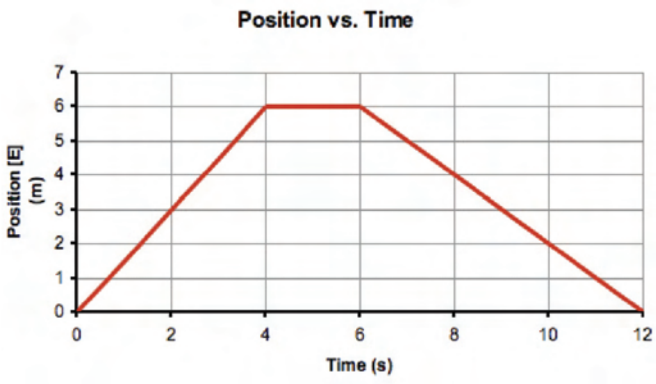
1. Remember:
   1 km = 1000 m
   1 h = 3600 s
2. To convert a velocity given in km/h to m/s:
   - Multiply by 1000 and divide by 3600.
     Or
   - Divide the speed in km/h by 3.6 to obtain the speed in m/s.
     Example: Convert 75 km/h to m/s.
     75 km/h × (1000 m/1 km) × (1 h/3600 s) = 21 m/s
     Or
     75 km/h ÷ 3.6 = 21 m/s

Quick Check

1. Convert 36 km/h into m/s.

2. Convert 20 m/s to km/h.

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
 The graph above shows the motion of an object. What is the average velocity of the object between 6.0 s and 10 s?	
A. 0 m/s	A. This is the average velocity over the entire graph, which begins and ends at the same point. In this question, we consider motion only between 6 s and 10 s.
B. 1.0 m/s [W]	B. This answer is correct. The average velocity is the slope of the graph during the time interval. At 6.0 s, the position of the object is 6.0 m [E]. At 10 s, the position of the object is 2.0 m [E]. slope = $\frac{(2.0 \text{ m} - 6.0 \text{ m})}{(10 \text{ s} - 6.0 \text{ s})}$ = −4.0 m / 4.0 s = −1.0 m/s or 1.0 m/s [W]
C. 5.0 m/s	C. This answer may be from counting spaces on the graph and dividing them. However, the actual scales need to be read. Also, since this is a velocity, the direction needs to be given.
D. 5.0 m/s [W]	D. This answer may be from counting spaces on the graph and dividing them. However, the actual scales need to be read.

➜ Why was this question asked?

This question was asked to determine if you can distinguish between distance and velocity and also whether you can calculate the slope of a line to determine average velocity.

➜ Where can I get extra practice on this type of question?

- Use pages 364 and 365 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
At the 2008 Olympic Games in Beijing, Michael Phelps won eight gold medals in swimming. In the 200 m freestyle, Phelps swam with a world record time of 1 min and 42.9 s. What was his winning average speed in m/s?	
A. 0 m/s	A. His average velocity was 0 m/s because his starting and ending position were the same. However, speed depends on the total distance covered.
B. 0.51 m/s	B. This was calculated by putting time in the numerator. Time needs to be in the denominator.
C. 1.94 m/s	C. This answer is correct. $v = \frac{200\ \text{m}}{102.9\ \text{s}}$ Note that $t = 60\ \text{s} + 42.9\ \text{s} = 102.9\ \text{s}$
D. 140 m/s	D. The time was incorrectly used. 1 min and 42.9 s is 60 s + 42.9 s = 102.9 s

➜ Why was this question asked?

This question was asked to determine if you can calculate speed and velocity.

➜ Where can I get extra practice on this type of question?

- Use pages 362 to 366 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

Section 8.2

Average velocity is the rate of change in position: Average Velocity

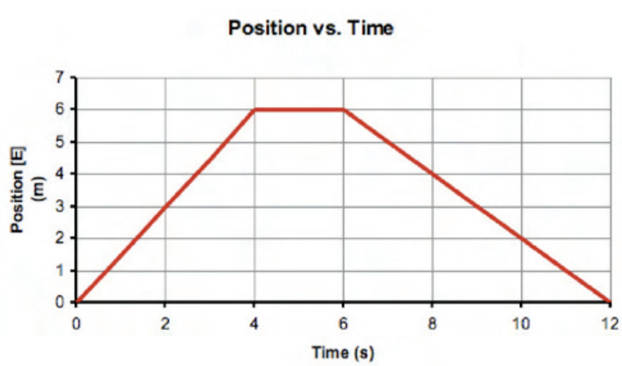
Circle the letter of the best answer.

1. What units are used to measure speed?
   A. s
   B. km
   C. m/s
   D. m/s^2

2. What is the average velocity of a baseball that travels 10 m [E] in 0.75 s?
   A. 7.5 m/s
   B. 10.0 m/s
   C. 11.3 m/s
   D. 13.3 m/s

3. A major league baseball pitcher throws a baseball with an average velocity of 28 m/s. How long would it take for the ball to travel the 18.5 m distance from the pitcher's mound to home plate?
   A. 0.33 s
   B. 0.66 s
   C. 1.3 s
   D. 1.5 s

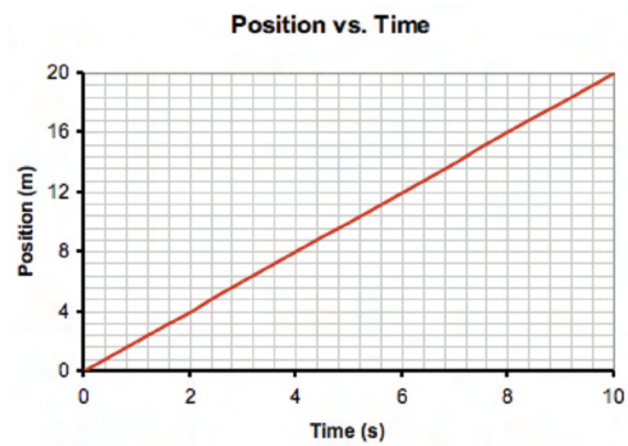
Use the following graph to answer questions 4 and 5.



4. Using the graph above showing the motion of an object, determine the average speed of the object.
   A. 1.0 m/s^2
   B. 1.5 m/s^2
   C. 1.0 m/s
   D. 1.5 m/s

5. What is the average velocity of the object described by the graph above?
   A. −1.0 m/s
   B. 0 m/s
   C. 1.0 m/s
   D. 1.5 m/s

Use the following graph to answer question 6.



6. What is the average velocity represented by the graph above?
   A. 0.5 m/s
   B. 1.0 m/s
   C. 2.0 m/s
   D. 10 m/s

7. On August 16, 2008, the 100 m sprint record was broken by Jamaican Usain Bolt running the distance in 9.69 s. What was Usain's average velocity?
   A. 9.3 m/s
   B. 9.72 m/s
   C. 10.3 m/s
   D. 10.5 m/s

8. A Formula One race car can move at an average velocity of 350 km/h. How far would the race car travel in 10 s?
   A. 972 m
   B. 102 m
   C. 97.2 m
   D. 1.2 km

9. What does the slope of a line in a position vs. time graph represent?
   A. time
   B. distance
   C. displacement
   D. average velocity

10. A Boeing 747 jet has an average cruising velocity of 780 km/h. How long would it take to fly the 675 km distance from Vancouver to Calgary?
   A. 69 min
   B. 52 min
   C. 42 min
   D. 35 min

Chapter 9 Acceleration is the rate of change in velocity.

9.1 Describing Acceleration

I. Summary of Key Points

- Acceleration is the rate of change in velocity.
- A change in velocity is calculated by subtracting the initial velocity from the final velocity.
- If an object's acceleration is in the same direction as its velocity, the object's speed increases.
- If an object's acceleration is in the opposite direction to its velocity, the object's speed decreases.
- Zero acceleration means that the object is moving at a constant velocity.

II. Study Notes

Uniform and Non-uniform Motion

1. An object travelling with uniform motion has equal displacements in equal time intervals.
2. An object travelling with non-uniform motion will:
   - have different displacements during equal time intervals
   - take different amounts of time to travel equal displacements
   - have a continuously changing velocity

Positive and Negative Changes in Velocity

1. A change in velocity ($\Delta\vec{v}$) occurs when the speed of an object changes and/or its direction of motion changes.
2. A change in velocity can be calculated by subtracting the initial velocity from the final velocity.
   $\Delta\vec{v} = \vec{v}_f - \vec{v}_i$
3. If the change in velocity is the same sign (+ or −) as the initial velocity, the speed of the object is increasing.
4. If the change in velocity is the opposite sign of the initial velocity, the speed of the object is decreasing.
5. If the change in velocity is zero, the object is travelling with uniform motion.

Quick Check

1. Calculate the following changes in velocity. Make sure you indicate whether the velocity change is positive or negative.
   (a) A pedestrian walking forward at 1.0 m/s speeds up to 3.0 m/s. ____________________________
   (b) A runner moving at 4.0 m/s slides into home plate, and crosses it at 1.0 m/s. _______________
   (c) A snowboarder sliding backward at 3.0 m/s changes velocity to 5.0 m/s backward. _________

Acceleration

1. **Acceleration** ($\vec{a}$) is the rate of change in velocity.
   - Acceleration can be due to a change in speed and/or a change in direction.
2. Two objects with the same change in velocity can have different accelerations because acceleration describes the rate at which the change in velocity occurs.

Positive and Negative Acceleration

1. The direction of the acceleration is the same as the direction of the change in velocity.
2. Acceleration that is opposite the direction of motion is sometimes called deceleration.
3. Remember that positive (+) and negative (–) refer to directions.
4. Examples of acceleration:
   - A car speeding up in the forward direction (Figure 9.1)
     If we designate the forward direction as positive (+), then the change in velocity is positive (+), therefore the acceleration is positive (+).

FIGURE 9.1 Since the car speeds up in a forward direction, its sign is positive.

   - A car slowing down in the forward direction
     If we designate the forward direction as positive (+), then the change in velocity is negative (–), therefore the acceleration is negative (–).
   - A car speeding up in the backward direction (Figure 9.2)
     If we designate the backward direction as negative (–), then the change in velocity is negative (–).
     – The acceleration is negative (–) even though the car is increasing its speed.

FIGURE 9.2 Since the car speeds up in a backward direction, its sign is negative.

   - A car slowing down in the backward direction
     If we designate the backward direction as negative (–), then the change in velocity is positive (+).
     – The acceleration is positive (+) even though the car is decreasing its speed.

Quick Check

1. What is acceleration? ______________________________

2. What are two ways that an object can change its velocity?
   ____________________ ____________________

3. What is deceleration? ______________________________

4. If a car is accelerating at –5.0 km/h, is it going backward or slowing down?
   ____

5. Give an example of something with a forward velocity experiencing a negative acceleration.
   ____

III. Sample Exam Questions Explained

The Question	Why It Is Right/ Why It Is Wrong
While a car is backing up, its velocity changes from −3 m/s to −9 m/s. What would be its total change in velocity?	
A. +12 m/s	A. Do not add the two velocities. Subtract the initial velocity from the final velocity.
B. +6.0 m/s	B. The final and initial velocities have been reversed in this answer. Remember to subtract the initial velocity from the final velocity, not the other way around.
C. − 6.0 m/s	C. This answer is correct. The car was already backing up and at the end of the time was backing up even faster than at the start. Since the change in velocity increases the rate of backward motion, the change in velocity is acting opposite to the forward direction. This makes the acceleration negative. $\Delta\vec{v} = \vec{v}_f - \vec{v}_i$ $= -9.0 \text{ m/s} - (-3.0 \text{ m/s})$ $= -6.0 \text{ m/s}$
D. −12 m/s	D. Do not add the two velocities. Subtract the initial velocity from the final velocity to find the change in velocity.

➜ Why was this question asked?

This question was asked to determine if you can use the equation that calculates the change in velocity.

➜ Where can I get extra practice on this type of question?

- Use pages 380 to 386 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
A rock is thrown up into the air and allowed to fall. If up is the positive direction, what kind of acceleration does the rock experience?	
A. zero acceleration	A. The acceleration is not zero as long as its velocity is changing. Regardless of the rock's velocity, even when it is stationary between rising and falling, its velocity is constantly decreasing due to the pull of gravity. This makes its acceleration negative.
B. negative acceleration	B. This answer is correct. The effects of gravity are acting against the positive direction of motion (up).
C. positive acceleration	C. Gravity is causing the rock to slow down.
D. both negative and positive acceleration	D. The speed upwards may change from positive (up) to negative (down), but the rate of change is always in the downward (negative) direction.

➜ Why was this question asked?

This question was asked to determine if you can recognize acceleration and distinguish it from velocity.

➜ Where can I get extra practice on this type of question?

- Use pages 380 to 386 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

Section 9.1

Acceleration is the rate of change in velocity: Describing Acceleration

Circle the letter of the best answer.

1. How is acceleration defined?
   A. the rate at which an object changes its velocity
   B. the difference between the initial time and the final time
   C. the rate at which an object travels over a given distance
   D. the displacement of an object during a time interval divided by the time interval

2. How is deceleration defined?
   A. the displacement of an object during a time interval divided by the time interval
   B. the difference between the initial time and the final time
   C. the rate at which an object travels over a given distance
   D. acceleration that is opposite the direction of motion

3. While a car is backing up, its velocity changes from −2.0 m/s to −7.0 m/s. What would be the total change in velocity?
   A. −9.0 m/s
   B. −5.0 m/s
   C. 5.0 m/s
   D. 9.0 m/s

4. A drag racer uses a parachute to slow down after reaching top speed at the racetrack. What kind of acceleration does the parachute create on the car?
   A. zero acceleration
   B. positive acceleration
   C. negative acceleration
   D. both negative and positive acceleration

5. What happens to the speed of an object if its acceleration is in the same direction as its velocity?
   A. The object will speed up.
   B. The object will slow down.
   C. The object's speed will not change.
   D. The object will begin to travel in the opposite direction.

6. A ball being dropped from a height accelerates at 9.8 m/s^2. Which of the following statements best describes the motion of the ball?
   A. The velocity increases and the acceleration increases.
   B. The velocity is constant and the acceleration increases.
   C. The velocity is constant and the acceleration is constant.
   D. The velocity increases and the acceleration is constant.

7. A Ferrari P4/5 race car goes from 0 km/h to 100 km/h in 3.55 s. What statement best describes the motion of the car?
   A. uniform motion
   B. zero acceleration
   C. positive acceleration
   D. negative acceleration

8. A horse that is running forward at 25 m/s stops and then backs up at 2.0 m/s. What is the horse's change in velocity?
   A. −27 m/s
   B. −23 m/s
   C. 23 m/s
   D. 27 m/s

9. A ball is thrown straight up into the air. On its way up, the ball's acceleration in is the downward direction. Which of the following statements is true?
   A. This ball has no acceleration.
   B. The ball is being slowed by gravity.
   C. The ball has acceleration in an upward direction.
   D. The ball is being accelerated by the thrower and gains velocity.

10. The Drop of Doom is a ride that accelerates you upward from 0 km/h to 80 km/h before plummeting you back to the ground, where you come to a rest at 0 km/h. What is the total change in velocity?
   A. 0 km/h
   B. 80 km/h
   C. It depends on acceleration and cannot be calculated from the information given.
   D. It depends on the height of the ride and cannot be calculated from the information given.

9.2 Calculating Acceleration

I. Summary of Key Points

- The slope of a velocity-time graph is average acceleration.
- Acceleration is measured in m/s^2.
- The relationship of acceleration, change in velocity, and time interval is given by the equation $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$.
- The acceleration due to gravity near the surface of Earth is 9.8 m/s^2 downward.

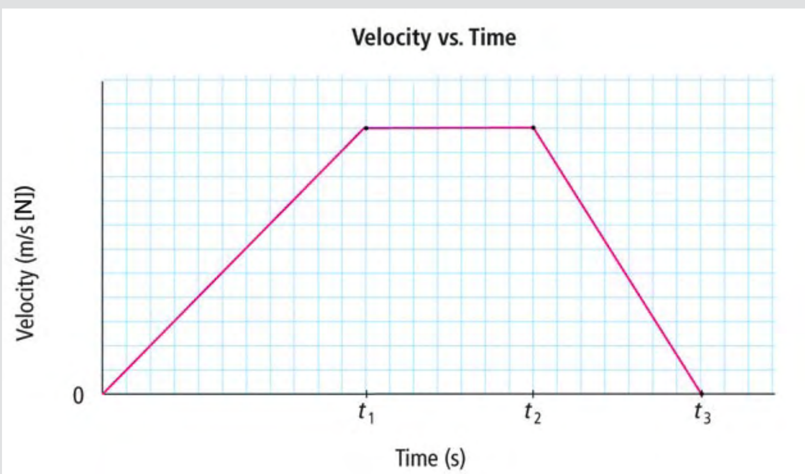
II. Study Notes

Velocity-Time Graphs and Determining Motion from a Velocity-Time Graph

1. The motion of an object with a changing velocity can be represented by a velocity-time graph.
   - The slope of a velocity-time graph is average acceleration.
2. **Positive acceleration** (positive slope) indicates the object's velocity is increasing in the positive direction.
3. **Zero acceleration** (zero slope) indicates the object's velocity is constant.
4. **Negative acceleration** (negative slope) indicates the object's velocity is decreasing in the positive direction or the object's velocity is increasing in the negative direction.

Quick Check

Use the velocity-time graph to answer the following questions.



1. State during which time interval:
   (a) the acceleration was zero ______________________________
   (b) the acceleration was negative ______________________________
   (c) the acceleration was positive ______________________________
   (d) the object was increasing its velocity N ______________________________
   (e) the object was decreasing its velocity N ______________________________
   (f) the object was moving at a constant velocity N ______________________________

Calculating Acceleration

1. Acceleration is measured in m/s^2.
2. The relationship of acceleration, change in velocity, and time interval is given by the equation $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$

Example: A pool ball travelling at 2.5 m/s towards the cushion bounces off at 1.5 m/s. If the ball was in contact with the cushion for 0.20 s, what is the ball's acceleration? (Assume towards the cushion is the positive.)

$\boldsymbol{a} = \frac{\Delta\vec{v}}{\Delta t}$

$= \frac{(-1.5 \text{ m/s} - 2.5 \text{ m/s})}{0.20 \text{ s}}$

$= \frac{-4.0 \text{ m/s}}{0.20 \text{ s}}$

$= -20 \text{ m/s}^2$

Quick Check

1. A truck starting from rest accelerates uniformly to 18 m/s [W] in 4.5 s. What is the truck's acceleration?

Calculating Change in Velocity and Time

1. The relationship of change in velocity, acceleration, and time interval is given by the equation $\Delta\vec{v} = (\vec{a})(\Delta t)$

Example: A car accelerates from rest at 3.0 m/s^2 forward for 5.0 s. What is the velocity of the car at the end of 5.0 s?

$\Delta\vec{v} = (\vec{a})(\Delta t)$

$= (3.0 \text{ m/s}^2)(5.0 \text{ s})$

$= 15 \text{ m/s}$

The car's change in velocity is 15 m/s forward, therefore:

$\Delta\vec{v} = \vec{v}_f - \vec{v}_i$

$15 \text{ m/s} = \vec{v}_f - 0$

$\vec{v}_f = 15 \text{ m/s}$

The car's velocity after 5.0 s is 15 m/s forward.

2. The relationship of time interval, change in velocity, and acceleration is given by the equation $\Delta t = \frac{\Delta\vec{v}}{\vec{a}}$

Example: A train is travelling east at 14 m/s. How long would to increase its velocity to 22 m/s [E], if it accelerated at 0.50 m/s^2 [E]? Assign E positive (+).

$\Delta\vec{v} = \vec{v}_f - \vec{v}_i = (22 \text{ m/s}) - (14 \text{ m/s}) = 8.0 \text{ m/s}$

To find the value of Δt:

$\Delta t = \frac{\Delta\vec{v}}{\vec{a}}$

$= \frac{8.0 \text{ m/s}}{0.50 \text{ m/s}^2}$

$= 16 \text{ s}$

It would take 16 s for the train to increase its velocity.

Quick Check

1. A toboggan moving 5.0 m/s forward decelerates backwards at –0.40 m/s^2 for 10 s. What is the toboggan's velocity at the end of the 10 s?

2. How much time does it take a car travelling south at 12 m/s to increase its velocity to 26 m/s south if it accelerates at 3.5 m/s^2 south?

Gravity and Acceleration, and **Calculating Motion Due to Gravity**

1. Objects near the surface of Earth fall to Earth due to the force of gravity.
   - Acceleration ($\vec{a}$) due to gravity is 9.8 m/s^2 downward.
2. To analyze situations where objects are accelerating due to gravity, use the equations:

   $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$

   $\Delta\vec{v} = (\vec{a})(\Delta t)$

   $\Delta t = \frac{\Delta\vec{v}}{\vec{a}}$

   Example: Suppose a rock falls from the top of a cliff. What is the change in velocity of the rock after it has fallen for 1.5 s? Assign "down" as negative (–).

   $\Delta\vec{v} = (\vec{a})(\Delta t)$

   $= (-9.8 \text{ m/s}^2)(1.5 \text{ s})$

   $= -15 \text{ m/s}$

   Since down is negative (–), the change in the rock's velocity is 15 m/s down.
3. Air resistance is a friction-like force that opposes the motion of objects that move through the air.
   - If the object is falling, air resistance acts upward on the object.
4. The amount of air resistance force depends on the speed, size, and shape of the object.
   - Air resistance is why a flat piece of paper falls more slowly than a crumpled piece of paper.
5. In the absence of air resistance all objects, regardless of their mass, would fall with the same acceleration.

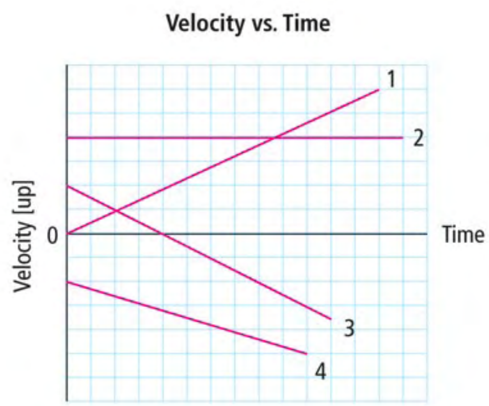
Quick Check

1. What is the change in velocity of a brick that falls for 3.5 s?

2. A ball is thrown straight up into the air at 14 m/s. How long does it take for the ball to slow down to an upward velocity of 6.0 m/s?

3. A rock is thrown downward with an initial velocity of 8.0 m/s. What is the velocity of the rock after 1.5 s?

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
 The graph above shows the motion of four different objects. The positive direction is up. Which object initially was moving up, then accelerated to a stop, and finally began accelerating downward?	
A. 1	A. This object was not moving at the start. Its velocity is shown at the start as zero. Its velocity increased constantly up, which means it was accelerating up.
B. 2	B. This object was moving up at the start. Its initial velocity (up) is shown as greater than zero. The line is horizontal meaning that its velocity is not changing. This object is moving up but not accelerating.
C. 3	C. This answer is correct. This object was moving up at the start. Its initial velocity (up) is shown as greater than zero. Its velocity is constantly getting smaller, as shown by a downward slope of the line. At the point the line crosses the *x*-axis, it has stopped. However, it continues to accelerate down after that.
D. 4	D. This object was moving down at the start. Its initial velocity (up) is shown as less than zero, which is what indicates that it is moving down. Its velocity continues to decrease (upward), which means that its velocity downward is increasing.

➜ Why was this question asked?

This question was asked to determine if you can use a velocity-time graph to interpret the motion of an accelerating object.

➜ Where can I get extra practice on this type of question?

- Use pages 392 to 400 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
A rock is thrown straight up into the air with an initial velocity of 30 m/s. How long does it take for the rock to reach its maximum height? (Assume the acceleration of gravity is 9.8 m/s^2 downward.)	
A. 0.33 s	A. This is the inverse of the correct answer. The values were substituted incorrectly into the formula, or the formula was incorrectly derived.
B. 3.1 s	B. This answer is correct. The moment the rock reaches its maximum height, its velocity is zero. This gives: $\vec{\boldsymbol{v}}_i = 30$ m/s $\vec{\boldsymbol{v}}_f = 0$ m/s $\vec{\boldsymbol{a}} = -9.8$ m/s The change in velocity can be calculated by: $\Delta\vec{\boldsymbol{v}} = \vec{\boldsymbol{v}}_f - \vec{\boldsymbol{v}}_i$ $= 0$ m/s $- 30$ m/s $= -30$ m/s $\Delta t = \Delta \frac{\vec{\boldsymbol{v}}}{\vec{\boldsymbol{a}}}$ $= \frac{-30 \text{ m/s}}{9.8 \text{ m/s}^2}$ $= 3.1$ s
C. 294 s	C. This is the product of the acceleration and the initial velocity. The formula may have been incorrectly derived.
D. It is not possible to answer the question because the maximum height is not known.	D. Even though the maximum height is not known, it is possible to determine how long it takes to get to the maximum height. This is because at the highest point, just between rising and falling, the velocity is zero. This information can be used to calculate $\Delta\vec{\boldsymbol{v}}$.

➜ Why was this question asked?

This question was asked to determine if you can recognize acceleration and distinguish it from velocity.

➜ Where can I get extra practice on this type of question?

- Use pages 392 to 400 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

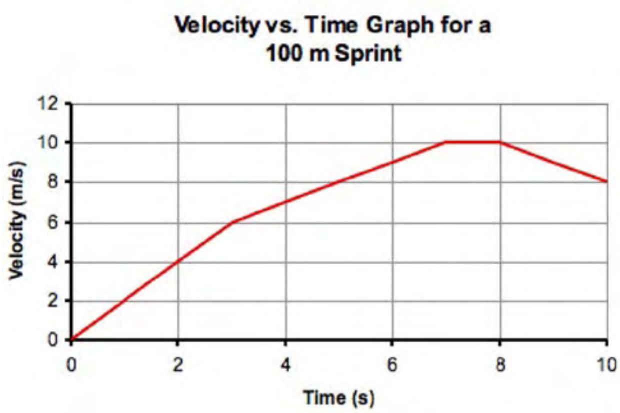
IV. Practice Questions

Section 9.2

Acceleration is the rate of change in velocity: Calculating Acceleration

Circle the letter of the best answer.

Use the graph below to answer questions 1 and 2.



1. The graph above shows the motion of a sprinter during a 100 m sprint. Where does the sprinter have the greatest acceleration?
   A. 0 to 3.0 s
   B. 3.0 to 7.0 s
   C. 7.0 to 8.0 s
   D. 8.0 to 10 s

2. What is the acceleration of the sprinter during the first 3 s of the race?
   A. $-2.0\ m/s^2$
   B. $-1.0\ m/s^2$
   C. $1.0\ m/s^2$
   D. $2.0\ m/s^2$

3. What is the SI unit for acceleration?
   A. m
   B. s
   C. m/s
   D. m/s^2

4. If a ball is thrown straight up into the air with an initial velocity of 24 m/s, how long does it take for the ball to reach its maximum height? (Assume the acceleration of gravity is $9.8\ m/s^2$ downward.)
   A. 2.0 s
   B. 2.4 s
   C. 4.2 s
   D. 9.8 s

5. A piece of a potato fired from a potato gun accelerates from rest to a velocity of 60 m/s in 0.08 s. What is the acceleration?
   A. $-650\ m/s^2$
   B. $650\ m/s^2$
   C. $750\ m/s^2$
   D. $7500\ m/s^2$

6. How long does it take a skier to accelerate from 28 m/s to 47 m/s if the skier is accelerating at $4.0\ m/s^2$?
   A. 3.7 s
   B. 4.75 s
   C. 47.5 s
   D. 76 s

7. A golf ball is struck from a tee and accelerates from rest at $560\ m/s^2$ forward. What is the velocity of the ball after 0.05 s?
   A. 1120 m/s
   B. 112 m/s
   C. 28 m/s
   D. 2.8 m/s

8. At what velocity will a penny strike the sidewalk if it is dropped from the Empire State Building and takes 11.27 s to fall the 373 m distance to the ground? You may ignore the effects of air resistance.

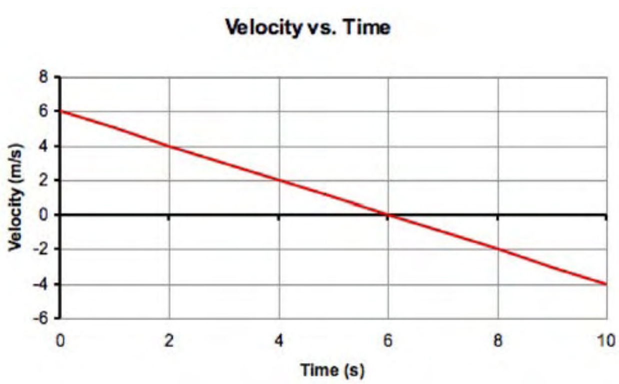
   (Remember that the acceleration due to gravity is -9.8 m/s^2.)

   A. 110.45 m/s
   B. −110.45 m/s
   C. 125.20 m/s
   D. −125.20 m/s

9. Which of the following is the factor with the greatest effect on the acceleration of an object falling due to gravity?

   A. Earth's magnetic poles
   B. the object's temperature
   C. the object's mass
   D. air resistance

Use the graph below to answer question 10.



10. Which statement below best describes what is happening to the object in the graph?

   A. The object has a constant velocity.
   B. The object is experiencing positive acceleration.
   C. The object is experiencing negative acceleration.
   D. This object is travelling in the same direction for this data set.

Processes of Science Vocabulary Terms

You may encounter the following Processes of Science vocabulary terms on the exam.

- ☐ **accuracy** the difference between a measurement and its accepted value
- ☐ **conclusion** the explanation of the results of an experiment as they apply to the hypothesis being tested
- ☐ **control** a test you carry out with no independent variables so you can observe whether your independent variable in an experiment does indeed cause a change
- ☐ **controlled experiment** an investigation in which only one variable is changed, and the resulting effect on another variable is observed, while all other variables are held constant
- ☐ **dependent variable** in an experiment, the factor that changes in response to a change in the independent variable; also called the responding variable
- ☐ **extrapolation** a prediction that is out of the range of the collected data
- ☐ **hypothesis** a testable proposal used to explain an observation or to predict the outcome of an experiment; often expressed in the form of an "If ..., then ..." statement
- ☐ **independent variable** in an experiment, the factor that is selected or adjusted to see what effect the change will have on the dependent variable; also called the manipulated variable
- ☐ **interpolation** a prediction that is within the range of collected data
- ☐ **observation** information gathered through one or more senses, including hearing, touch, sight, taste, and smell
- ☐ **precision** a measure of the detail, such as the number of digits, with which a quantity is expressed
- ☐ **prediction** a forecast about what you expect to observe when you do an investigation
- ☐ **principle** a fundamental law, assumption, or fact
- ☐ **procedure** a specific set of actions which if executed in the same manner under the same circumstances will yield the same results
- ☐ **scale** ratio between a single unit of distance, such as on a map, model, or drawing, and the corresponding distance in reality
- ☐ **scientific literacy** an evolving combination of the science-related attitudes, skills, and knowledge necessary to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world
- ☐ **slope** the direction of a line on a graph, which may be horizontal (zero), slanting up (positive), or slanting down (negative). Slope is calculated by determining the ratio of rise/run.
- ☐ **uncertainty** a lack of certainty; having limited knowledge to describe a state or outcome, often where more than one outcome is possible
- ☐ **validity** the degree to which a conclusion is likely to be true
- ☐ **variable** a factor that can influence the outcome of an experiment
- ☐ **Venn diagram** a type of graphic organizer that can be used to compare and contrast two or more concepts or objects by using two or more intersecting circles

Unit 3 Glossary

acceleration ($\vec{a}$) the rate of change in velocity

displacement ($\Delta\vec{d}$) the straight-line distance and direction from one point to another

distance (d) the length of a path between two points or locations

magnitude the size of the measurement or the amount you are counting

negative acceleration indicates the object's velocity is decreasing in the positive direction or the object's velocity is increasing in the negative direction

position ($\vec{d}$) a specific point relative to a reference point

positive acceleration indicates the object's velocity is increasing in the positive direction

slope the direction of a line on a graph, either horizontal (zero), slanting up (positive), or slanting down (negative). Slope is calculated by determining the ratio of $\frac{\text{rise}}{\text{run}}$.

speed (v) the distance an object travels during a time interval divided by the time interval

time interval (Δt) the difference between the final time and the initial time (when the event began)

uniform motion travelling in equal displacements in equal time intervals; neither speeding up, slowing down, nor changing direction

velocity ($\vec{v}$) the displacement of an object during a time interval divided by the time interval; a change in velocity is represented by $\Delta\vec{v}$, initial velocity is $\vec{v}_i$, and final velocity is $\vec{v}_f$

zero acceleration indicates the object's velocity is constant

Part C – Unit 3 Answer Key

Chapter 8

Quick Check Answers

page 4

1. (a) Scalar
   (b) Vector
   (c) Scalar
   (d) Vector
   (e) Scalar

page 5

1. (a) 5 s
   (b) 2 s
2. (a) Distance describes the length of a path between two points or locations.
   (b) Position describes a specific point relative to a reference point.
   (c) Displacement describes the straight-line distance and direction from one point to another.

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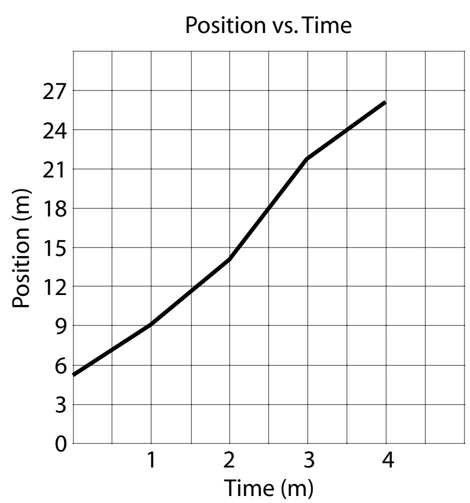
1. (a) 10 m [S]
   (b) 5.0 m/s down
   (c) +20 cm/h
   (d) 50 km/h [E]
   (e) +15 km

page 7

1. Sample graph:



2. (a) No
   (b) The object travels different distances during different time intervals.

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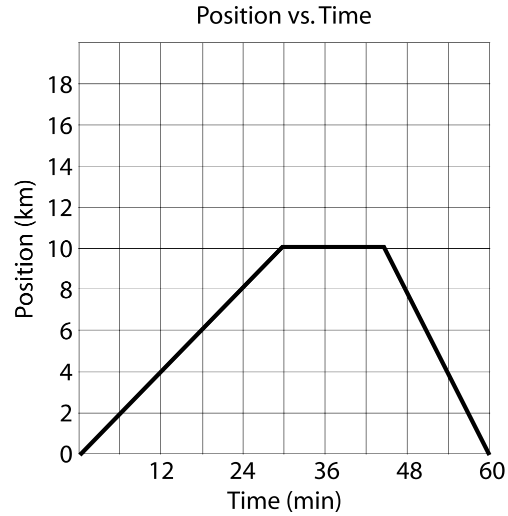
1. Sample graph:



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1. (a) displacement
   (b) distance

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1. (a) Jogger A
   (b) The slope is steeper.
2. (a) t_1 to t_2
   (b) 0 to t_1
   (c) t_2 to t_3

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1. 2.3 m/s [E]
2. 120 m [N]
3. (a) 5.0 m/s
   (b) 0.5 m/s [W]
   (c) 4. 15 s

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1. 10 m/s
2. 72 km/h

Practice Questions Answers

Section 8.1

1. D
2. A
3. A
4. C
5. B
6. D
7. A
8. A
9. C
10. B

Section 8.2

1. C
2. D
3. B
4. C
5. B
6. C
7. C
8. A
9. D
10. B

Chapter 9

Quick Check Answers

page 20

1. (a) +2 m/s
   (b) −3 m/s
   (c) −2 m/s

page 21

1. Acceleration is the rate of change in velocity.
2. Speed, direction of motion (or both)
3. Deceleration is acceleration that is opposite the direction of motion.
4. The car is slowing down, as indicated by the negative sign in front of the acceleration. (It is not possible from the information given to know whether the car is moving forwards or backwards, only that it is slowing down.)
5. Accept any answer indicating an object that is moving forward while also slowing down.

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1. (a) t_1 to t_2
   (b) t_2 to t_3
   (c) 0 to t_1
   (d) 0 to t_1
   (e) t_2 to t_3
   (f) t_1 to t_2

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1. 4.0 m/s [W]

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1. 1.0 m/s forward
2. 4.0 s

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1. 34 m/s downward
2. 0.82 s
3. 23 m/s downward

Practice Questions Answers

Section 9.1A

1. A
2. D
3. B
4. C
5. A
6. D
7. C
8. A
9. B
10. A

Section 9.2

1. A
2. D
3. D
4. B
5. C
6. B
7. C
8. A
9. D
10. C