

In order for these exercises to help build your physics skills and understanding, you need to ensure you complete them and that the work that goes into them is always thoughtful. If you skim the exercises you are likely to gain little.

A: Reflect on the Grade 11 Motion Unit

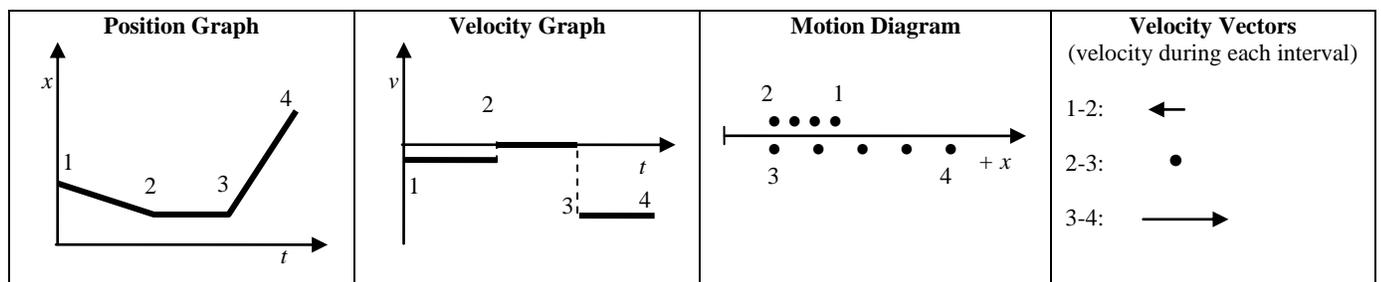
- Reflect.** Do you recall what aspects of the motion unit you had difficulties with? For example: graphing, accelerated motion, the BIG 5 equations, freefall, writing solutions, or maybe something else!
- Commitment.** Are you willing to put in the effort to improve your skills to so you will do well in grade 12? (circle one)
 Very willing Somewhat willing Indifferent Not really willing
- Reason.** The most important step in these exercises is carefully correcting your work and identifying what aspects you had difficulty with. Explain why this is so.

B: Interpreting Graphs

When we interpret graphs in physics, we go through two important steps: (1) identify the mathematical features of the graph, and (2) interpret the physical meaning of the mathematical features. Always go through these two steps in your own mind when you interpret graphs – even if a question doesn’t ask! The chart below is a summary of different features of a graph and their physical interpretations.

Graph Feature	Math	Position	Velocity
Value	The “y” axis reading at that time value	The value of the position at that moment in time	The value of the instantaneous velocity at that moment in time
Sign of the values	Above or below the t -axis	On which side of the origin the object is located	The direction of velocity
Slope	Positive or negative slope	Direction of velocity	Direction of acceleration
Slope	Steep or shallow	Fast or slow	Large acceleration or small acceleration
Area	Area of shape formed by graph and t -axis	No meaning	Displacement during the time interval

Here is one set of graphs and motion representations for one example of a student moving in front of a motion detector. The positive direction is to the right. Examine the representations and answer the questions below.



- Interpret.** During the interval 1-2, the object is moving slowly in the negative direction. Explain how you can figure that out from **each** representation.

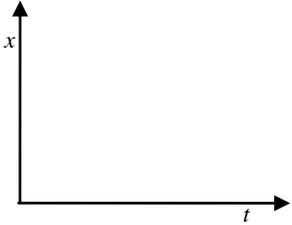
The answers to each question are found below¹. **Cover up the page or place a Post-It note or two over the answers.** Don't cheat and look at the answers until you are 100% complete, or else all this effort will not help build your skills. When you correct your answers **use a different colour** to check off each idea that is correct. Also use this colour to write any additions or corrections into your answer. Following all these steps is important!

2. **Feedback.** You just corrected your first answer. Write some advice to yourself that coaches you on what or how to improve.

3. **Interpret².** Explain how each representation allows you to decide what is happening between events 2 and 3.

4. **Reason³.** During the interval 3-4, one of the representations is incorrect. Explain.

5. **Represent.** A student walks in front of a motion detector according to the following description. Construct each representation to illustrate how they moved. (1) The student stands still a distance from the detector, (2) the student starts moving slowly, away from the detector with a constant speed, (3) the student suddenly turns around and begins moving towards the detector quickly, and (4) the student reaches the detector. (Answers on the next page! Don't look yet!)

Position Graph	Velocity Graph	Motion Diagram	Velocity Vectors (velocity during each interval)
			1-2: 2-3: 3-4:

6. **Evaluate.** Drawing the representations based on the description is often the hardest. Correct your work for question B#5. Keep in mind that some differences are not important, while others are. Overall, describe anything you need to remember to improve.

¹ Question B#1:

Position graph: shallow slope = slow, negative slope = negative direction
Velocity graph: values close to t-axis = slow, values below t-axis = negative direction
Motion diagram: dots close together = slow, dots moving left = negative direction
Velocity vectors: arrow length is short = slow, arrow pointing left = negative direction

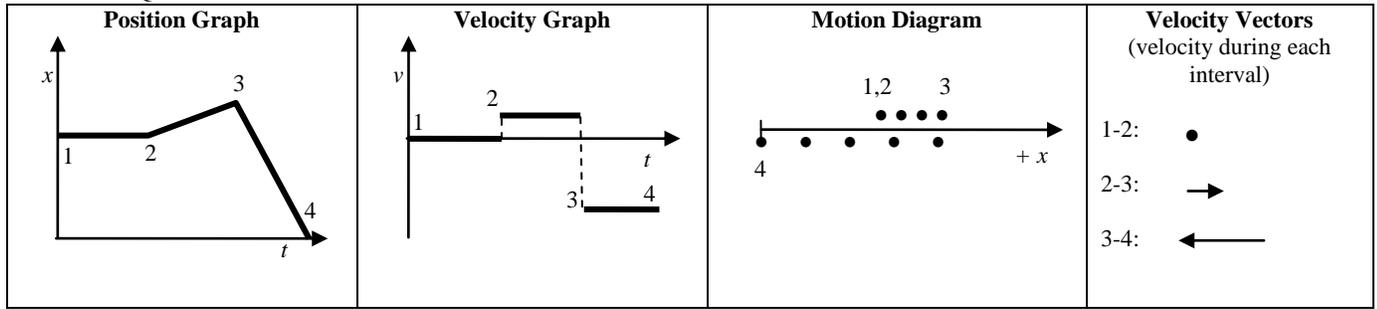
² Question B#3:

Position graph: slope = 0 means velocity zero, it is at rest *Velocity graph: values are all zero, it is at rest*
Motion Diagram: dots 2 and 3 are at same position, it was at rest *Velocity vectors: no vector, velocity is zero*

³ Question B#4:

Three representations show the student moving quickly in the positive direction during interval 3-4 (position graph, motion diagram, velocity vectors). The velocity graph shows the student moving quickly in the negative direction, which does not agree with the others.

Answers to Question B#5



C: Exploring Accelerated Motion

All the examples so far have involved intervals with constant velocity. Now it is time to explore accelerated motion.

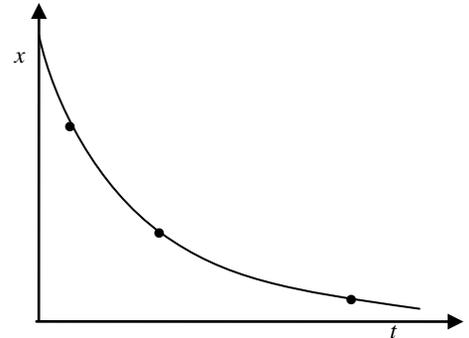
Speeding Up and Slowing Down

Whether an object speeds up or slows down depends on **both** the direction of its velocity and the direction of its acceleration.

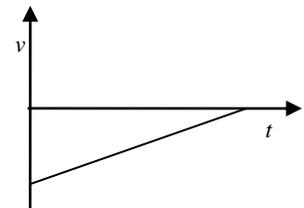
	Conditions	Position Graph	Velocity Graph	Acceleration Graph
Speeding Up	both the acceleration and velocity point in the same direction (the acceleration “helps” the velocity)	Size of slope = speed and slopes become steeper	Values of graph get further from zero	Can’t tell!
Slowing Down	the acceleration and velocity point in opposite directions (the acceleration “works against” the velocity)	Size of slope = speed, slopes become more shallow	Values from graph get closer to zero	No way to tell!

The slope of a tangent to a position graph gives the instantaneous velocity; the size of the slope is the instantaneous speed.

- Interpret⁴**. The position graph to the right shows the motion of a fan cart on a track. Draw tangents at each point on the graph. Describe what is happening to the size of the slopes. Is the object speeding up or slowing down? Explain.



- Interpret⁵**. The velocity graph to the right shows the motion of a car traveling along York Mills Rd.
 - Use the changing values of the graph to explain whether the car is speeding up or slowing down.



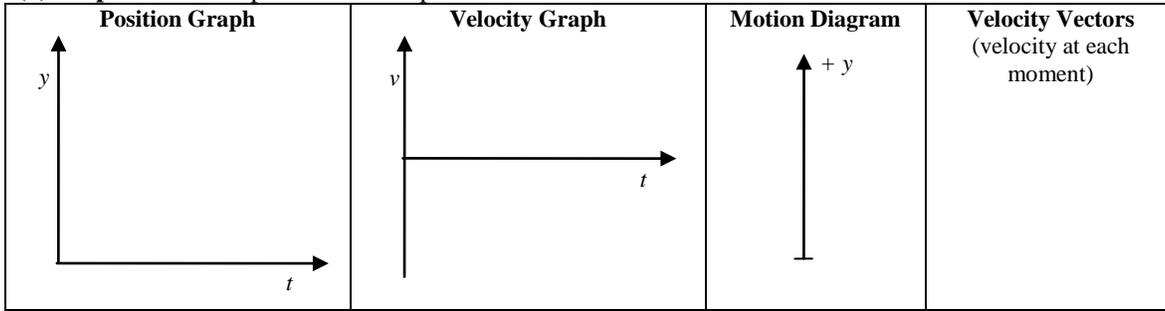
- Use the direction of the velocity and acceleration to explain whether the car is speeding up or slowing down.

- A ball leaves Isaac’s hand (1) and travels upward in the air. It reaches its highest point (2) and reaches the ground (3). We are not interested in the motion of the ball while it is in contact with Isaac’s hand or the ground. Upwards is positive.
 - Reason⁶**. How does the vertical position of the ball at moment 1 compare with moment 3?

⁴ Question C#1: the slopes become shallower which means the cart is slowing down.

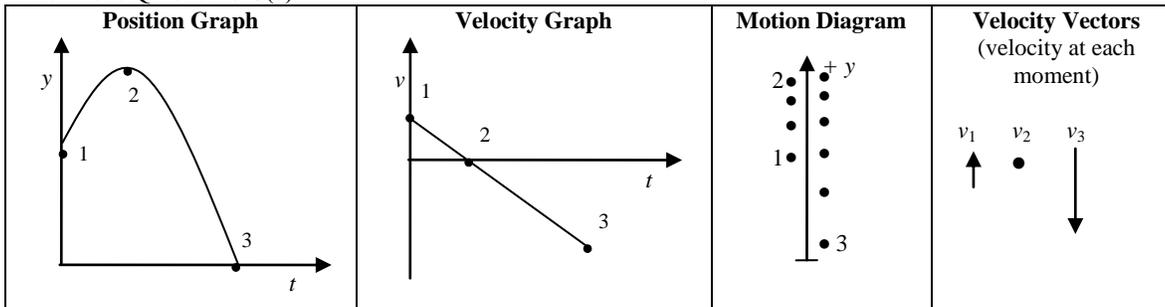
⁵ Question C#2: (a) the values get closer to zero (the time axis), which means the car is slowing down. (b) The velocity values are negative (below the time axis) and the acceleration is positive (the slope). Since these are in opposite directions, the car slows down.

(b) **Represent.** Complete the four representations below to illustrate the motion of the ball.



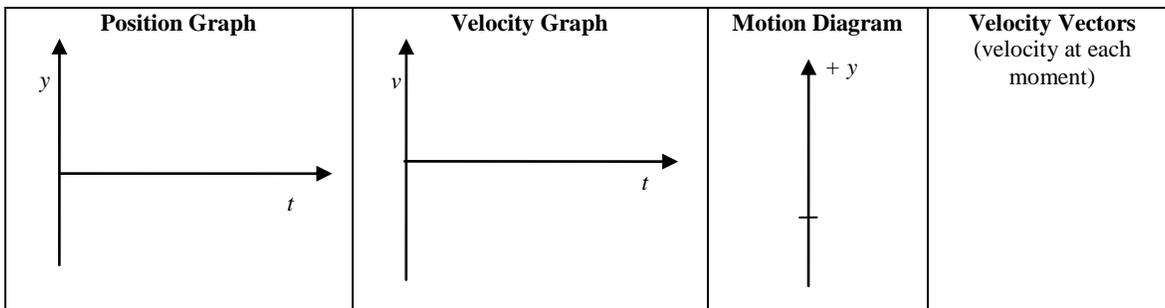
4. **Evaluate.** The graph should show one interval slowing down and one interval speeding up: label these. Correct your representations using the answers below. Use a different colour, as usual. What aspects of your answers did you find needed the most improvement?

Answers to Question C#3(b)



5. Emmy steps off a diving platform (1), reaches the water surface (2), and reaches the deepest point in the water (3). We will assume Emmy accelerates at a constant rate in the water. The water surface is the origin.
- (a) **Reason**⁷. Does Emmy's acceleration change at any moment in time?

(b) **Represent.** Complete the four representations of motion for Emmy. Complete parts (c) and (d) before your correct your representations.



- (c) **Interpret**⁸. During the first interval of time 1-2, is Emmy speeding up or slowing down? Describe how each representation help you decide.

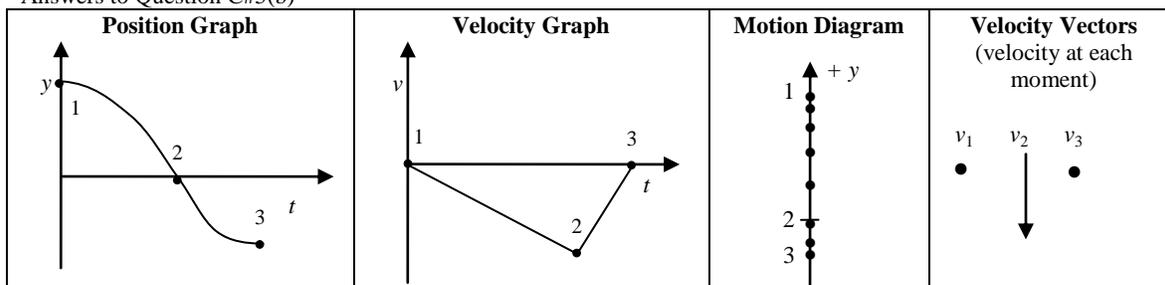
⁶ Question C#3(a): When it leaves her hand, it is higher up than when it reaches the ground.

⁷ Question C#5(a): When she reaches the water surface, her net force changes, so her acceleration also changes.

(d) **Reason**⁹. Explain how you can use the four different representations to check they all agree with one another.

(e) **Evaluate**. Correct your representations using the answers below. This example has a lot of detail in it, so take your time correcting your work using a different colour. Has your understanding changed about anything you drew?

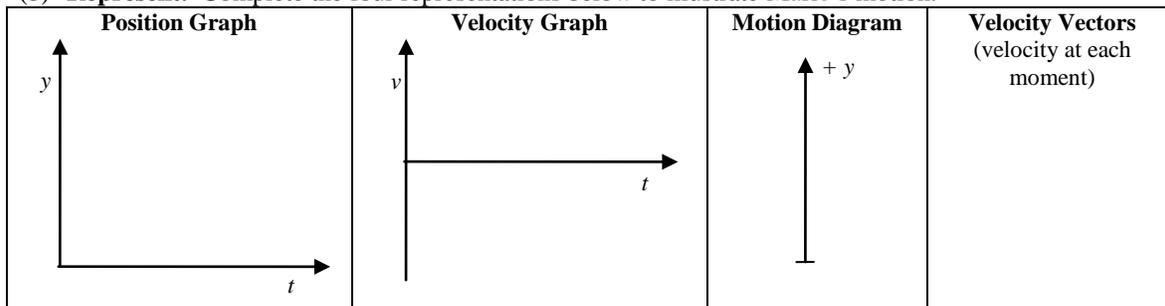
Answers to Question C#5(b)



6. Marie leaps up off the floor with a powerful jump. (1) Marie is crouched and begins to push upward off the floor, (2) Marie leaves contact with the floor, and (3) Marie reaches her highest point in the air. Upwards is positive.

(a) **Reason**¹⁰. Does Marie's acceleration change at any moment in time? Why?

(b) **Represent**. Complete the four representations below to illustrate Marie's motion.



(c) **Interpret**¹¹. How can you tell from the velocity graph that Marie's acceleration changes?

(d) **Evaluate**. Correct your representations using the answers below. What did you need to improve?

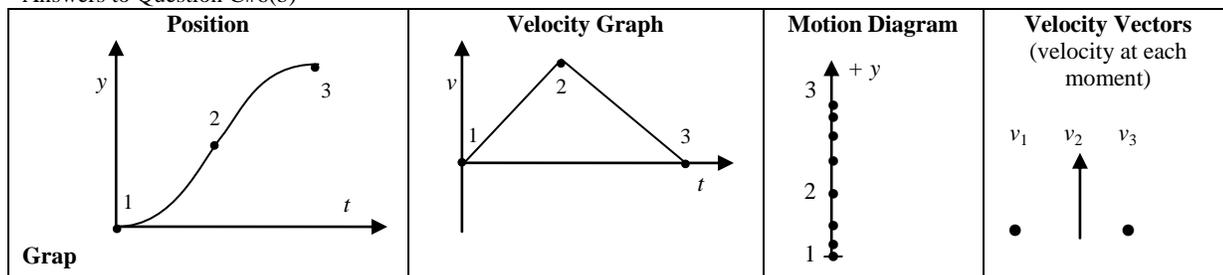
⁸ Question C#5(c): *Position graph: the slopes become steeper; Velocity graph: the values get farther from the time axis; Motion diagram: the spacing between the dots increases; Velocity vectors: the length of the vectors increases.*

⁹ Question C#5(d): *Go through each diagram or graph interval by interval. Each interval should describe the same motion. When I finish my representations, I will start with the first interval of each and interpret them, making sure they agree.*

¹⁰ Question C#6(a): *When her feet leave contact with the floor (moment 2), the net force she experiences changes, so according to Newton's 2nd law, her acceleration must change as well.*

¹¹ Question C#6(c): *The slope of a velocity graph gives the acceleration. Since her acceleration changes at moment 2, the slope of the velocity graph changes from negative to positive.*

Answers to Question C#6(b)



(e) Reason¹². Albert takes a look at the velocity graph you have drawn. He says, “During interval 2-3 the graph is going down. That’s when Marie was traveling back down, right?” Help explain to Albert his difficulty understanding the graph.

D: Describing Motion

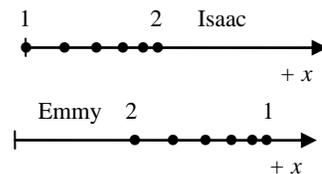
When we describe the motion of an object, whenever possible, we try to describe something about its position, velocity and acceleration.

- **Position:** where does it start or end
- **Velocity:** moving fast or slow, moving in the positive or negative direction
- **Acceleration:** direction, speeding up or slowing down, any changes of acceleration due to change of net force

1. Describe¹³. Isaac and Emmy each take turns walking in front of a motion detector. Use the two motion diagrams to describe how they moved.

(a) Isaac:

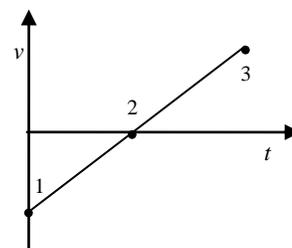
(b) Emmy:



2. Describe¹⁴. A yo-yo is released from Albert’s hand, travels down and then back up. Use the velocity graph to describe in detail to motion of the yo-yo. Down is negative.

(a) Events 1-2:

(b) Events 2-3:



3. Evaluate. Check your answers to the description questions. What should you do or remember to improve your descriptive work?

¹² Question C#6(e): The negative slope might be confusing him: on a position graph, a negative slope would mean travelling downwards, but on a velocity graph it means a negative acceleration. The velocity values are always positive during interval 2-3 so Marie is still moving upwards.

¹³ Question D#1(a): Isaac is at the origin and is moving quickly in the positive direction. He is slowing down, with a negative acceleration, until he stops; (b) Emmy starts at rest, far from the origin. She speeds up with a positive acceleration.

¹⁴ Question D#2(a): The yo-yo begins high up and is moving quickly in the negative direction. As it travels down, it slows down and reaches a velocity of zero at the bottom. (b) Then it begins to travel upwards and speeds up as it returns to the hand. The acceleration is always positive.