Name: _____

Lesson 3.12. Purple Arrows on the Velocity Graph

Date: _____ Period: _____

In the previous lesson, you learned how to determine the *total change of velocity* over any time interval by calculating the length of the corresponding brown arrow on a velocity graph. I now wish to introduce to you a particular change: the change of velocity that occurs during each time interval of ***one unit***. By *one unit*, I mean one second, one minute, one week, one century; it does not matter as long as it's *one* of some unit of time. On the velocity graph, the *change of velocity per unit interval* is represented by a purple arrow and its dotted line.

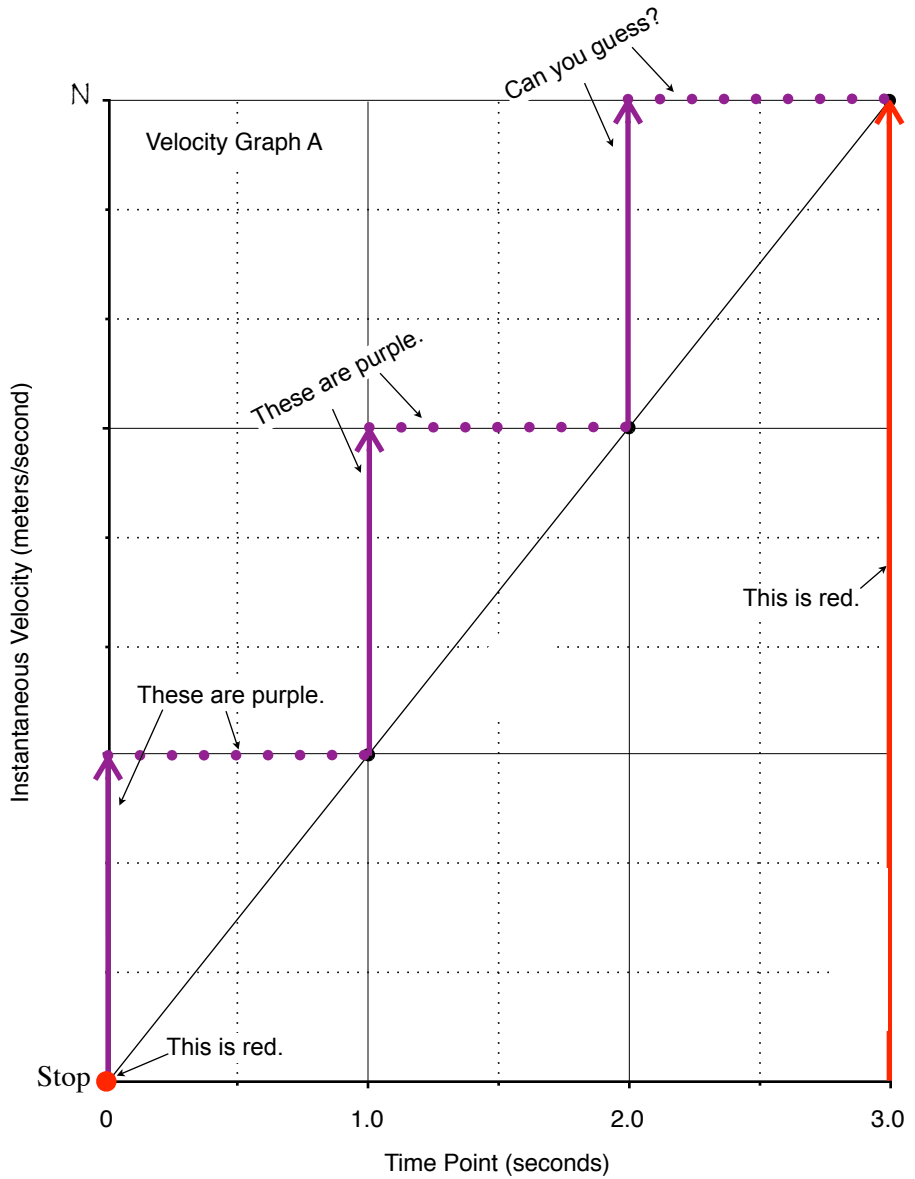
Consider Velocity Graph I at right. During every interval of one second, the object goes faster by 3 m/s, northward. Thus, we say that its velocity increases by 3 m/s ***per second***, northward.

The special name for the *change of velocity per unit time interval* is ***acceleration*** and its symbol is ***a***.

This is to make it plain that this is not just any ol' change; rather, it is a change ***per unit time interval***.

You already have experience with a *change per unit time interval:* ***velocity*** is the change of *position* per unit time interval.

- ***Velocity*** is the change of *position* per unit time interval. *Velocity* is represented on the *position* graph by red arrows and their dotted lines. A unit of velocity is *miles per hour*.
- ***Acceleration*** is the change of *velocity* per unit time interval. *Acceleration* is represented on the *velocity* graph by purple arrows and their dotted lines. A unit of acceleration is *miles per hour, per second*.



It turns out that physicists often use negative signs differently from the way other people use negative signs. For example, compare how physicists and bankers use negative signs:

- If Wynne Nerr has \$100 in her bank account, and Lou Zir has –\$100 in his bank account, who has more money? _____
- On the other hand, if Wynne is traveling at 70 mph, and Lou is traveling at–70 mph, who is traveling faster? _____

In the above scenarios, Wynne has a *lot* more money in her bank account than Lou, but they are traveling with equal speeds!

What *is* the difference between a velocity of 70 mph and a velocity of –70 mph? _____

_____

One may also compare negative *changes* and positive *changes*.

- For example, during the weekend, the balance in Wynne's account changed by \$200, while the balance in Lou's account changed by –\$200. Whose account decreased in value? Carefully explain your answer. _____

  _____

  _____

- On the other hand, if Wynne's velocity started at 70 mph and changed by 10 mph, and Lou's velocity started at –70 mph and changed by –10 mph, did either one of them press the brake pedal? Carefully explain your thinking. If you do not know, then read on! However, it would be best if you at least *tried* to answer by yourself first.

  _____

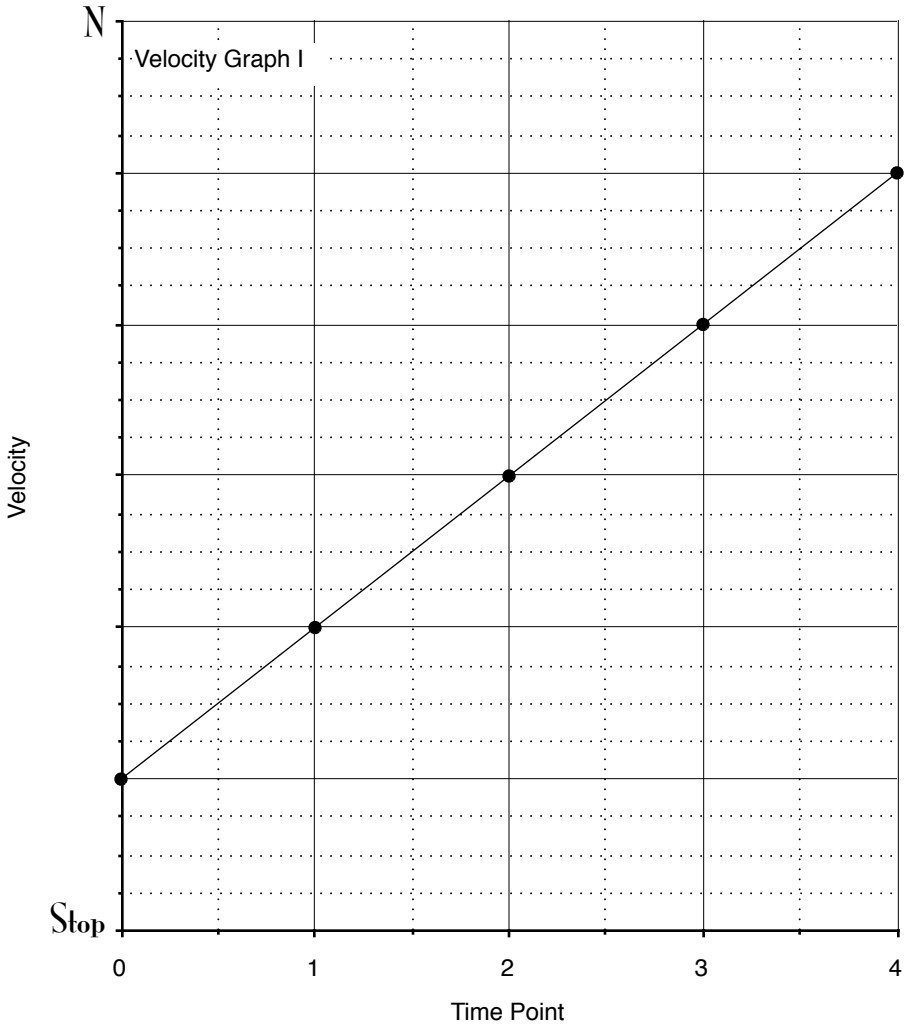
  _____

  _____

In the above scenario, both drivers pressed the *accelerator* pedal: Wynne ended up traveling at 80 mph, Nward, and Lou ended up traveling at 80 mph, Sward.

A banker would say that a negative change in a bank account balance *always* means there is less money; a physicist would say that a negative change of velocity *may* mean the object is traveling faster!

In this lesson, you will figure out the *rule* that explains how you can tell whether the velocity increases or decreases if you know the direction of motion and the direction of *acceleration*.

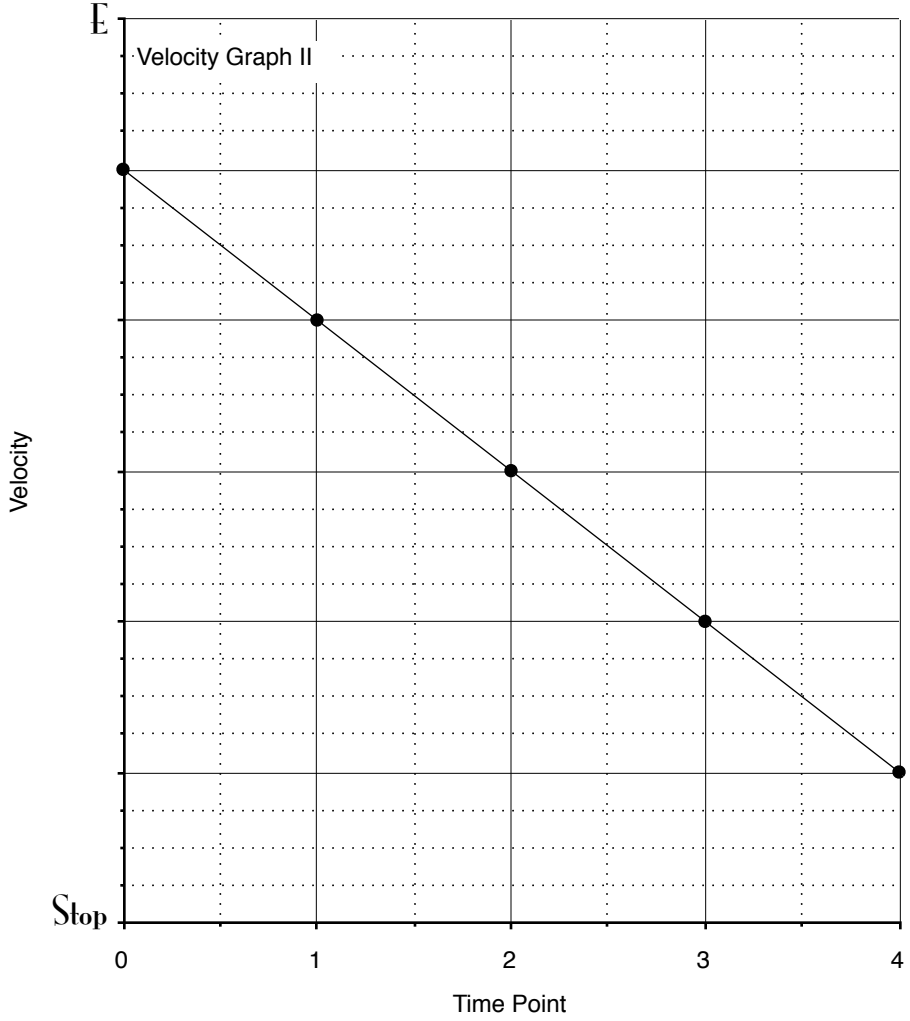


Consider Velocity Graph I above.

- ✦ In what direction did the object travel? _____
- ✦ Did the velocity increase, or did it decrease? _____

☐ ***Draw*** a red *instantaneous velocity* arrow at each time point across the graph.

☐ ***Draw*** purple *acceleration* arrows and their dotted lines for each time interval of one unit across the graph.



Consider Velocity Graph II above.

- ✦ In what direction did the object travel? _____
- ✦ Did the velocity increase, or did it decrease? _____

☐ ***Draw*** a red *instantaneous velocity* arrow at each time point across the graph.

☐ ***Draw*** purple *acceleration* arrows and their dotted lines for each time interval of one unit across the graph.

We now seek a *pattern* between the relative directions of the red and purple arrows and the increase or decrease of velocity. If we find such a pattern, then our task will be to determine the *rule* that describes the pattern. Such a *rule* will explain how you can tell whether the velocity increases or decreases if you know the direction of motion and the direction of *acceleration*.

First, organize the important information.

For Velocity Graph I:

- ✦ In what direction (upward, or downward) do the red *velocity* arrows point?

_____

- ✦ In what direction (upward, or downward) do the purple *acceleration* arrows point?

_____

- ✦ What happened to the value of *velocity* (increase, or decrease) from one time point to the next?

_____

For Velocity Graph II:

- ✦ In what direction (upward, or downward) do the red *velocity* arrows point?

_____

- ✦ In what direction (upward, or downward) do the purple *acceleration* arrows point?

_____

- ✦ What happened to the value of *velocity* (increase, or decrease) from one time point to the next?

_____

Next, test for patterns. For each question, you must observe *both* Graph I ***and*** Graph II.

Pattern 1

a) What happened to the value of *velocity* (increase, or decrease) when the purple *acceleration* arrows pointed *upward* (in the *positive* direction)?

_____

b) What happened to the value of *velocity* when the purple *acceleration* arrows pointed *downward* (in the negative direction)?

_____

c) What pattern is suggested by your answers to 1a and 1b? _____

_____

_____

Pattern 2

a) What happened to the *velocity* (increase, or decrease) when the red *velocity* arrows and the purple *acceleration* arrows pointed in the *same* direction?

_____

b) What happened to the *velocity* (increase, or decrease) when the red *velocity* arrows and the purple *acceleration* arrows pointed in *opposite* directions?

_____

c) What pattern is suggested by your answers to 2a and 2b? _____

_____

_____

_____

Name: _____

Homework 3.12. Purple Arrows on the Velocity Graph

Date: _____ Period: _____

Please perform the following tasks neatly, in pencil, ***right on the printed sheets!*** *I do not read messy work and I do not read work done in ink.*

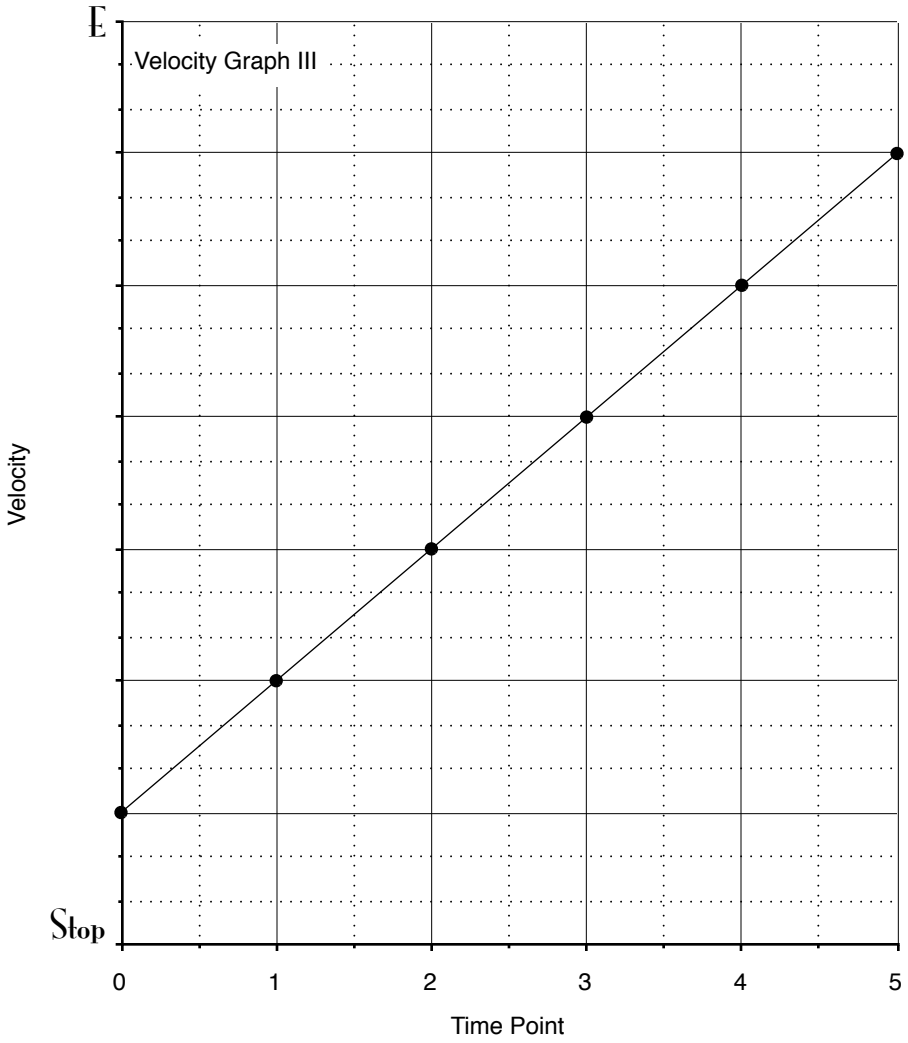
Express yourself in complete thoughts written in clear, declarative English sentences that connect the ideas in the question with the ideas in your answer.

At the end of the lesson, you described two patterns that appear to explain how you can tell whether the velocity increases or decreases if you know the direction of motion and the direction of *acceleration*. Please carefully describe each pattern here.

Pattern 1: _____

Pattern 2: _____

Your task now is to determine which of these patterns holds true for *all cases*.

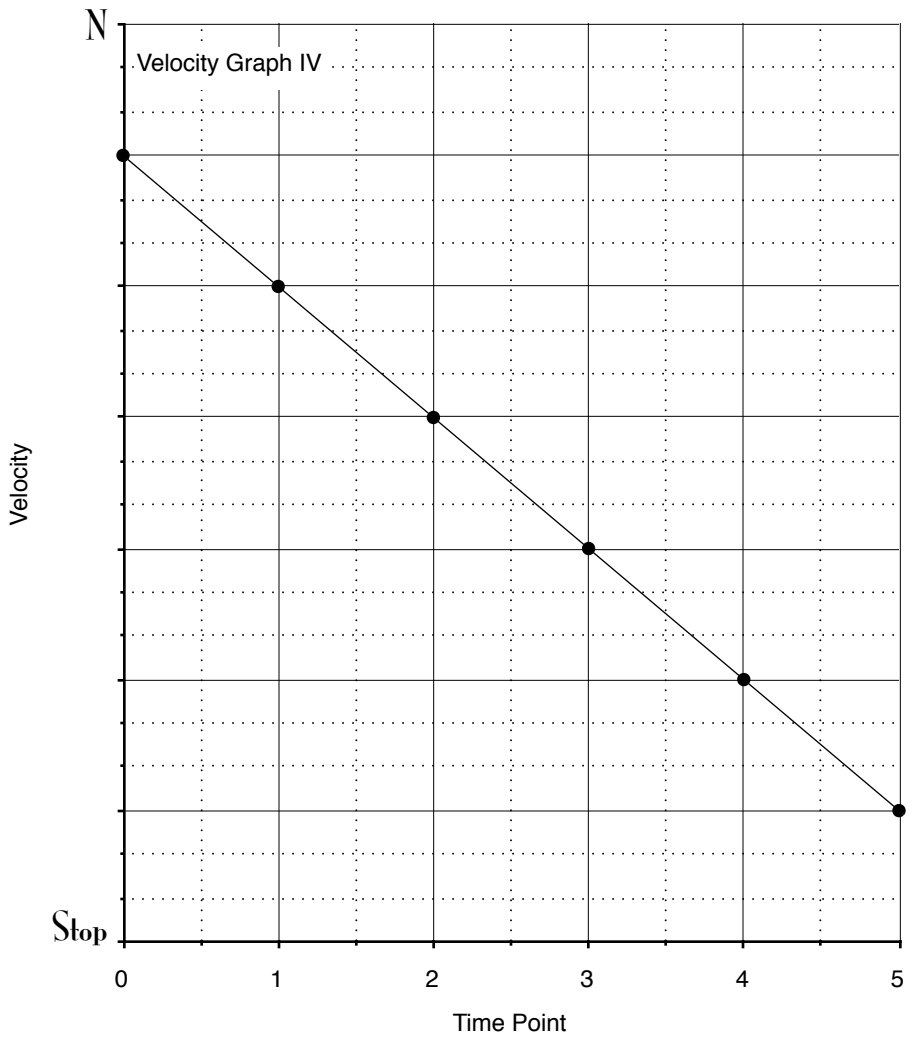


Consider Velocity Graph III above.

- ✦ In what direction did the object travel? _____
- ✦ Did the velocity increase, or did it decrease? _____

☐ ***Draw*** a red *instantaneous velocity* arrow at each time point across the graph.

☐ ***Draw*** purple *acceleration* arrows and their dotted lines for each time interval of one unit across the graph.

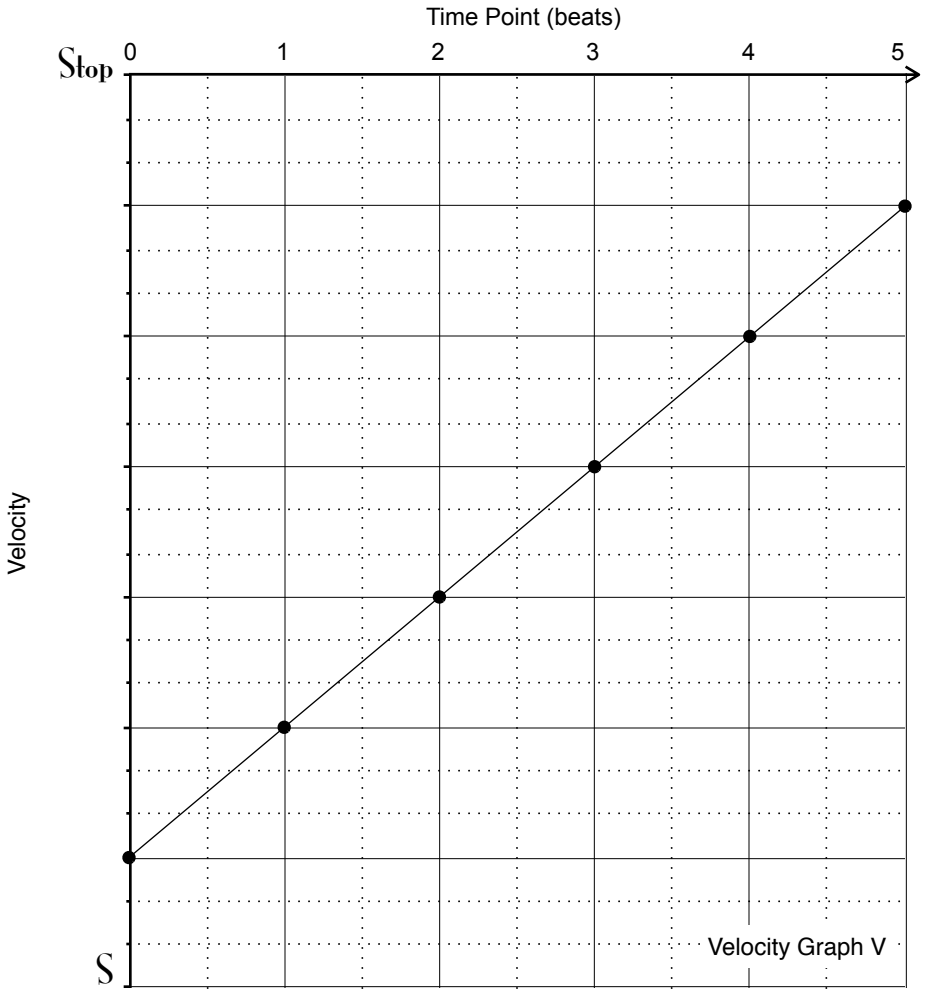


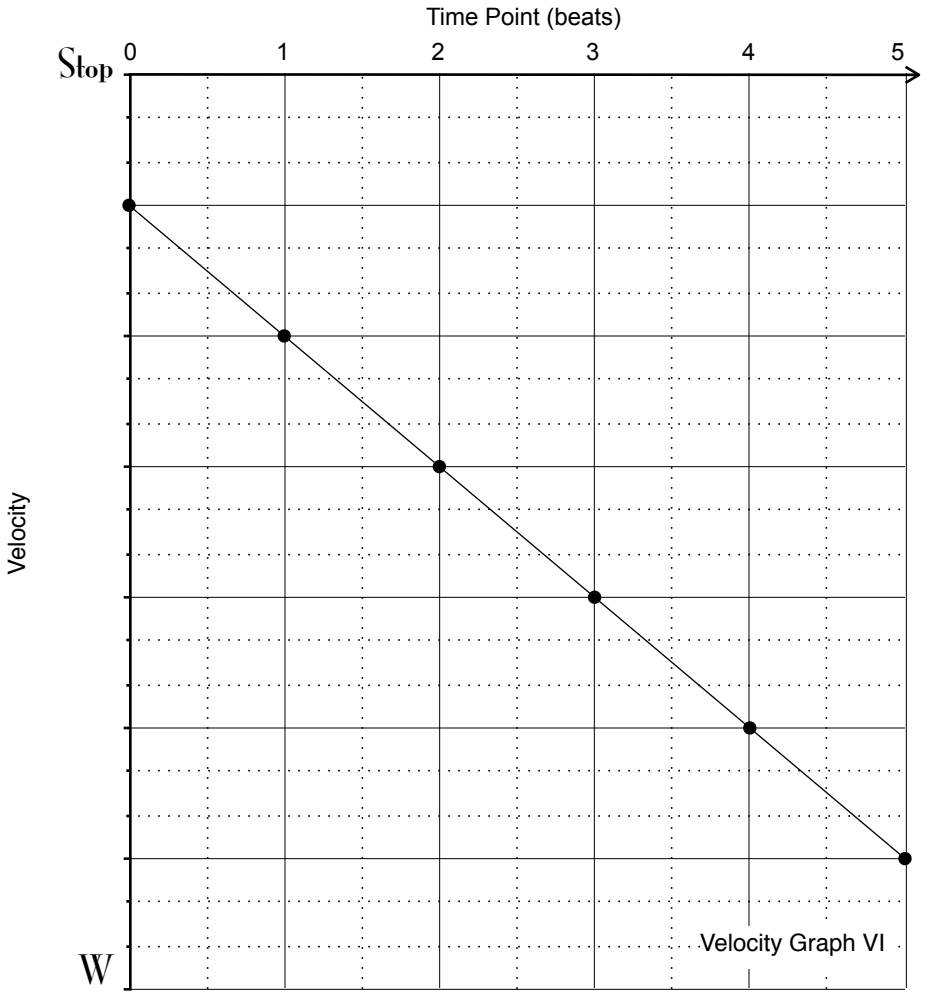
Consider Velocity Graph IV above.

- ✦ In what direction did the object travel? _____
- ✦ Did the velocity increase, or did it decrease? _____

☐ ***Draw*** a red *instantaneous velocity* arrow at each time point across the graph.

☐ ***Draw*** purple *acceleration* arrows and their dotted lines for each time interval of one unit across the graph.





Consider Velocity Graph V above.

- ✦ In what direction did the object travel? _____
- ✦ Did the velocity increase, or did it decrease? _____
- ☐ ***Draw*** a red *instantaneous velocity* arrow at each time point across the graph.
- ☐ ***Draw*** purple *acceleration* arrows and their dotted lines for each time interval of one unit across the graph.

Consider Velocity Graph VI above.

- ✦ In what direction did the object travel? _____
- ✦ Did the velocity increase, or did it decrease? _____
- ☐ ***Draw*** a red *instantaneous velocity* arrow at each time point across the graph.
- ☐ ***Draw*** purple *acceleration* arrows and their dotted lines for each time interval of one unit across the graph.

*Please answer the following questions **right here on the printed sheet!** Express yourself in complete thoughts written in clear, declarative English sentences that connect the ideas in the question with the ideas in your answer.*

1) List the graphs ***in the homework assignment*** that represent motion with *increasing* velocity. _____

How do you know the velocity increased? _____

a) On the graphs you listed, which way did the purple *acceleration* arrows point?

- ☐ The purple *acceleration* arrows pointed upward (in the positive direction).
- ☐ The purple *acceleration* arrows pointed downward (in the negative direction).
- ☐ Sometimes the purple *acceleration* arrows pointed upward, and sometimes they pointed downward.

b) On the graphs you listed, compare the directions of the red *instantaneous velocity* arrows and the purple *acceleration* arrows.

- ☐ The red *instantantous velocity* arrows and the purple *acceleration* arrows pointed in the *same* direction.
- ☐ The red *instantaneous velocity* arrows and the purple *acceleration* arrows pointed in *opposite* directions.
- ☐ Sometimes the red and purple arrows pointed in the same direction, and sometimes they pointed in opposite directions.

c) State the pattern that held true for ***all*** of the trials you listed. _____

2) List the graphs ***in the homework assignment*** that represent motion with *decreasing* velocity. _____

How do you know the velocity decreased? _____

a) On the graphs you listed, which way did the purple *acceleration* arrows point?

- ☐ The purple *acceleration* arrows pointed upward (in the positive direction).
- ☐ The purple *acceleration* arrows pointed downward (in the negative direction).
- ☐ Sometimes the purple *acceleration* arrows pointed upward, and sometimes they pointed downward.

b) On the graphs you listed, compare the directions of the red *instantaneous velocity* arrows and the purple *acceleration* arrows.

- ☐ The red *instantantous velocity* arrows and the purple *acceleration* arrows pointed in the *same* direction.
- ☐ The red *instantaneous velocity* arrows and the purple *acceleration* arrows pointed in *opposite* directions.
- ☐ Sometimes the red and purple arrows pointed in the same direction, and sometimes they pointed in opposite directions.

c) State the pattern that held true for ***all*** of the trials you listed. _____

3) Based upon your answers to 1c and 2c above, state a *rule* that explains how you can tell whether the velocity increases or decreases if you know the direction of motion and the direction of *acceleration*.

_____

_____

_____