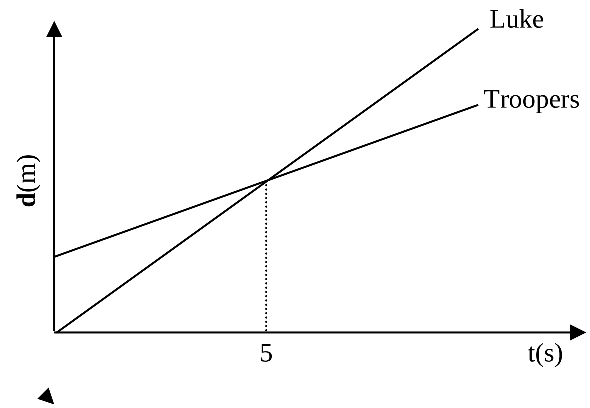
SPH3U: Delivery! Position – Time Graphs

Answers: 0) 130 m [W], 260 m [W], 390 m [W], 0 m, 1) 2, 2) 30 s, 3) 390 m [W], 4) 13 m/s [W], 5) East, 6) 20 m/s (going east), 7) 780 m, 8) 0 m, 9) 7.8 m/s, 10) 0 m/s

The Speeder Bike Chase!

Luke is chasing Imperial Troopers on the forest moon of Endor riding on Speeder Bikes, as shown in the **position-time** graph below.



1. Do Luke and the Troopers start at the same point? How do you know? If not, which is ahead?

Troopers start ahead, at a position away from origin

2. At t= 7s, who is ahead? How do you know?

Luke is ahead, his position is farther away from the origin

3. Who is travelling faster at 3s? How do you know?

Luke is traveling faster because the slope of his line is steeper

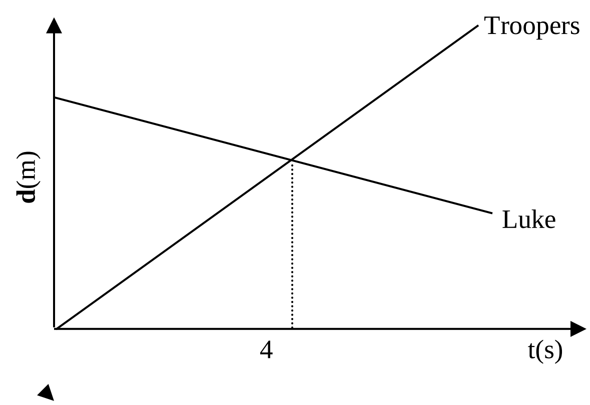
4. Are their velocities equal at any time? How do you know?

No, the slopes are constant (= constant velocities), and Luke's slope is always steeper

5. What is happening at the intersection of the two lines?

They are at the same position, Luke has overtaken the troopers

In the next dramatic scene, the motion is different:



6. How does Luke's motion in this graph compare to that in the first graph?

Luke is moving towards the origin, not away from it.

7. Who has the greater speed? How do you know?

The trooper line has the greater slope, so they are going faster

8. Describe what is happening at the intersection of the lines.

They are passing by each other in opposite directions, they are at the same position

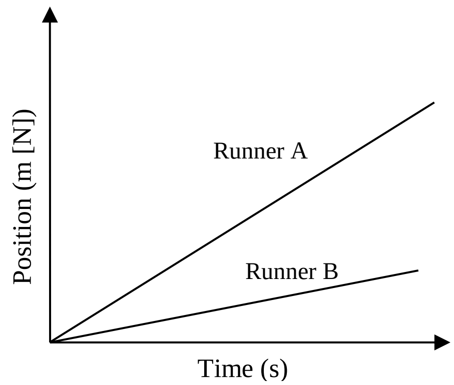
9. Who has travelled further during the first 4 seconds? How do you know?

The troopers – their displacement in the first 4 seconds is greater than Luke's

SPH3U: Position-Time Graphs and Velocity

On a **position-time** ($\vec{d} - t$) graph, the slope of the graph represents ____velocity_______.

Graph A

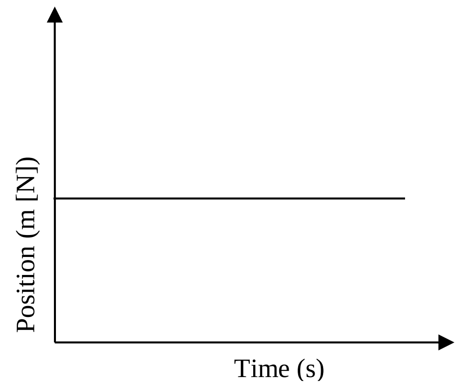


The graphs are **straight:** __constant _ velocity.

The **slope** of the graphs are **positive:** objects are traveling in the ___+___ **direction**.

The **steeper** the slope of the graphs, the __greater______ the **velocity**.

Graph B

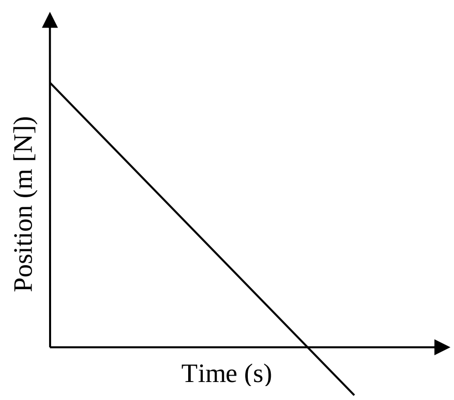


The graph is **straight:** _constant_____ velocity.

The **slope** of the graph is ___0______**:** the object is not moving.

The **velocity** of the object is ___0______.

Graph C

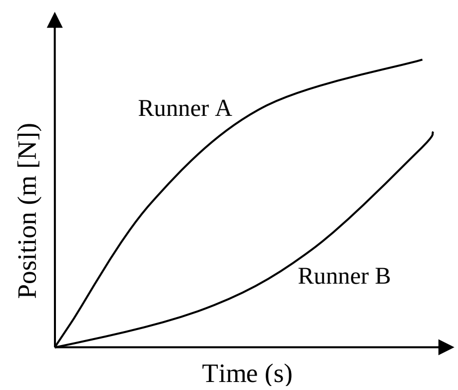


The **slope** of the graph is **negative:** object is traveling _towards____ the reference point.

The graph is **straight:** ___constant___ velocity.

*Note: constant velocity = uniform velocity

Graph D



The **slope** of the graphs are **positive** (objects are traveling in the __+____ **direction),** but the graphs are **not straight**: __non-uniform____ motion.

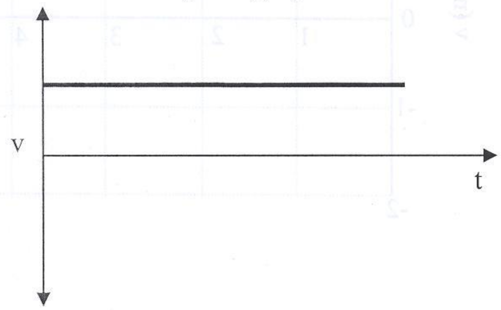
The slope of Runner A is decreasing: runner A is ___slowing down____.

The slope of Runner B is increasing: runner B is ___speeding up_______.

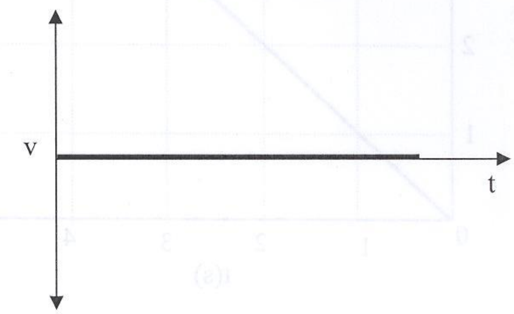
SPH3U: Position and Velocity Graphs Name:

Sketch a motion map and v-t graph corresponding to the following descriptions of the motion of an object.

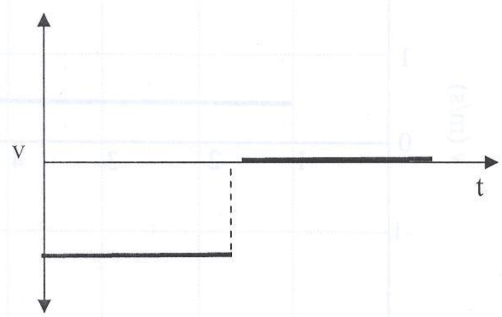
1. The object is moving away from the origin at a constant (steady) speed.



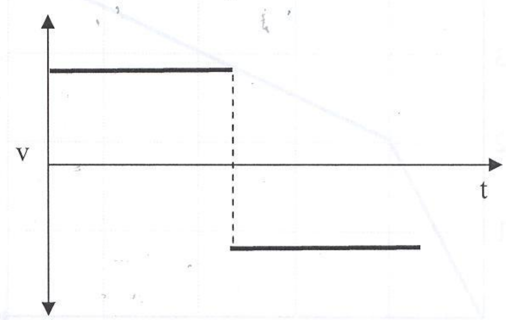
2. The object is standing still

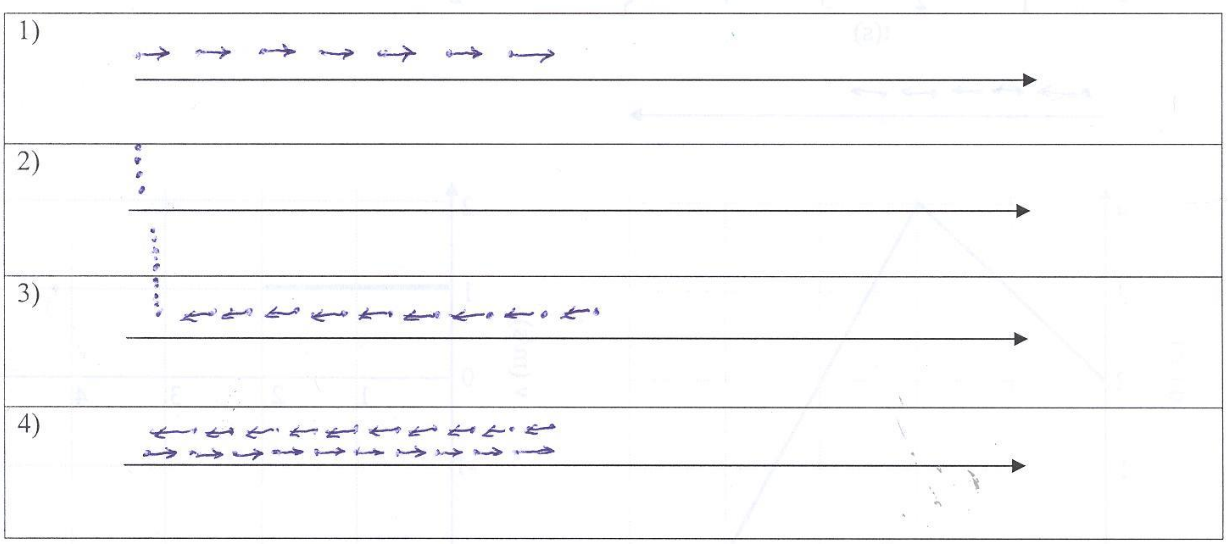


3. The object moves towards the origin at a steady speed for 10 s, then stands still for 10 s.

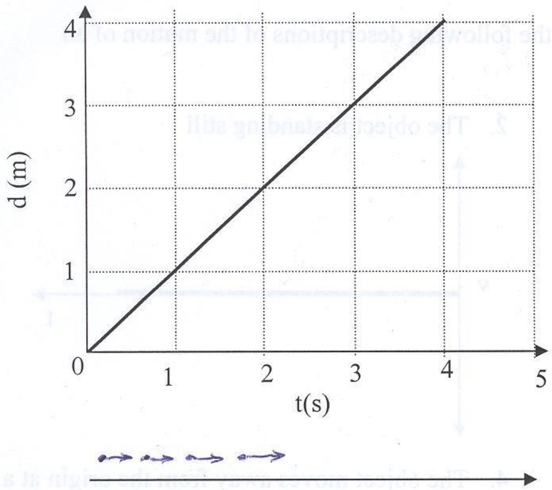


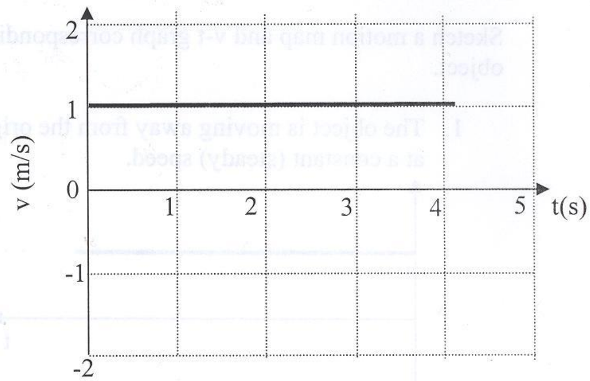
4. The object moves away from the origin at a steady speed for 10 s, then reverses direction and moves back toward the origin at the same speed.

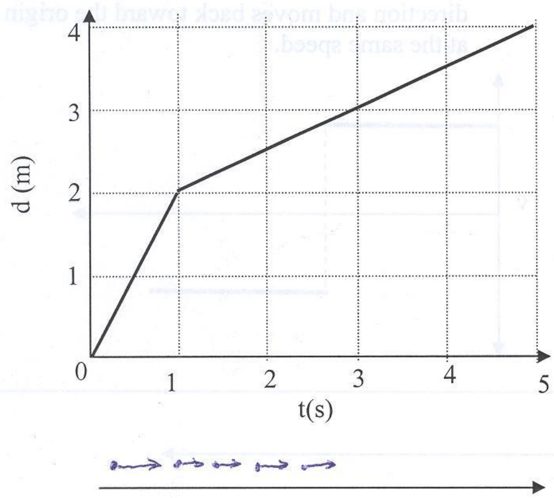


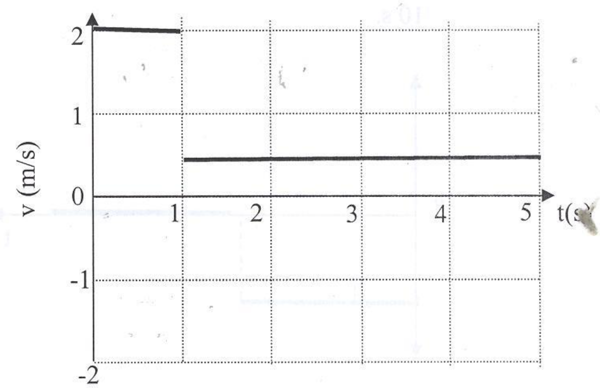


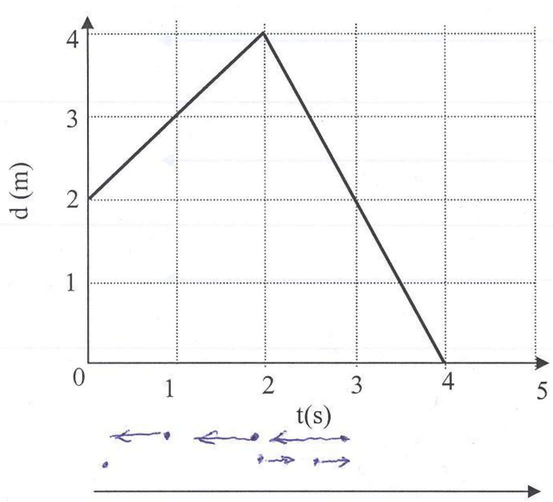
Draw v-t graphs and a motion map for an object whose motion produced the d-t graphs shown below.

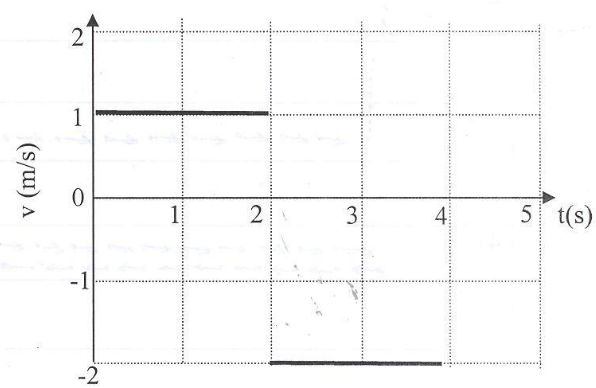






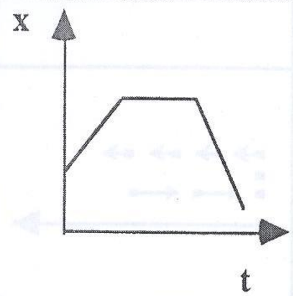
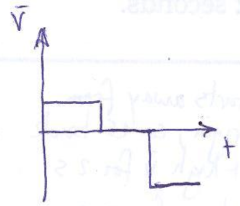
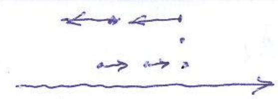
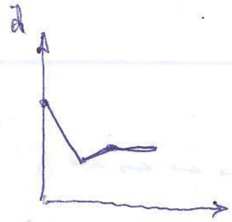
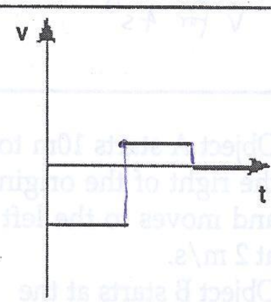
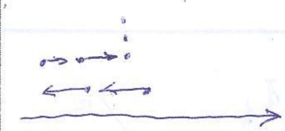
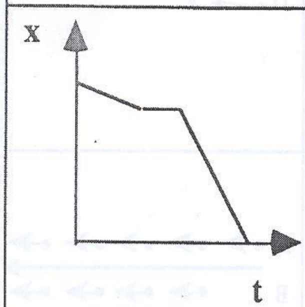
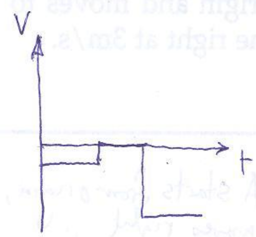
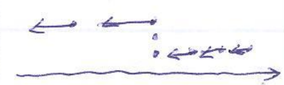
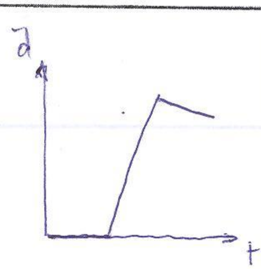
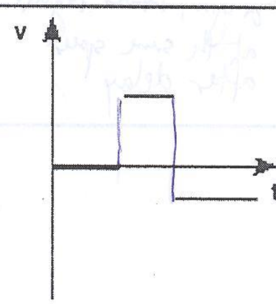
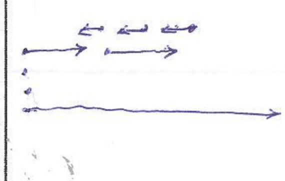


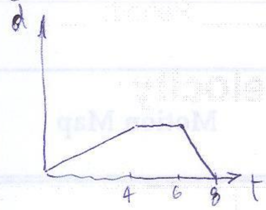
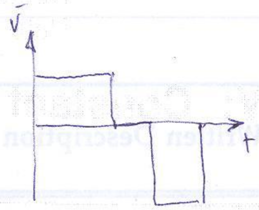
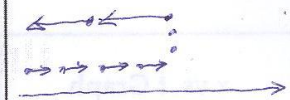
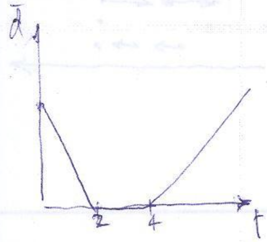
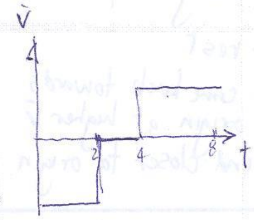
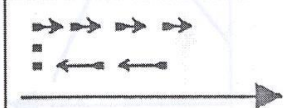
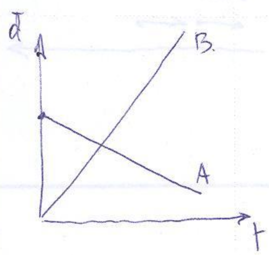
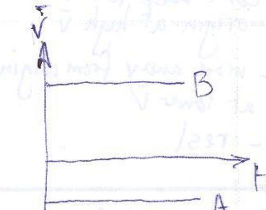
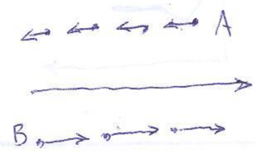
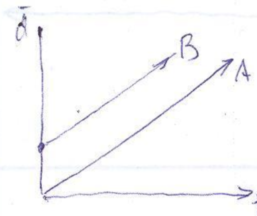
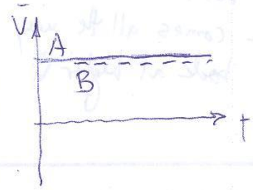
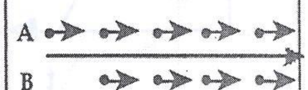




SPH3U: Representations of Motion and Constant Velocity

Name:

x vs. t Graph	v vs. t Graph	Written Description	Motion Map
		- start away from origin, moving away - rest - come back towards origin at higher v̄ - end closer to origin	
		(assumes starting away from origin) - come back towards origin at high v̄ - move away from origin at lower v̄ - rest	
		- starts away from origin, comes back at low v̄ - rest - comes all the way back at higher v̄	
		- start at rest - move away from origin at high speed - come back towards origin part way at lower speed	

		Object moves with constant positive velocity for 4 seconds. Then, it stops for 2 seconds and returns to the initial position in 2 seconds.	
		- starts away from origin, comes back at high $\bar{v}$ for 2 s - stops for 2 s - moves away at lower $\bar{v}$ for 4 s	
		Object A starts 10m to the right of the origin and moves to the left at 2 m/s. Object B starts at the origin and moves to the right at 3m/s.	
		A starts from origin, moves right B starts to right of origin, moves right at the same speed after delay	

SPH3U: Velocity-Time Graphs and Displacement

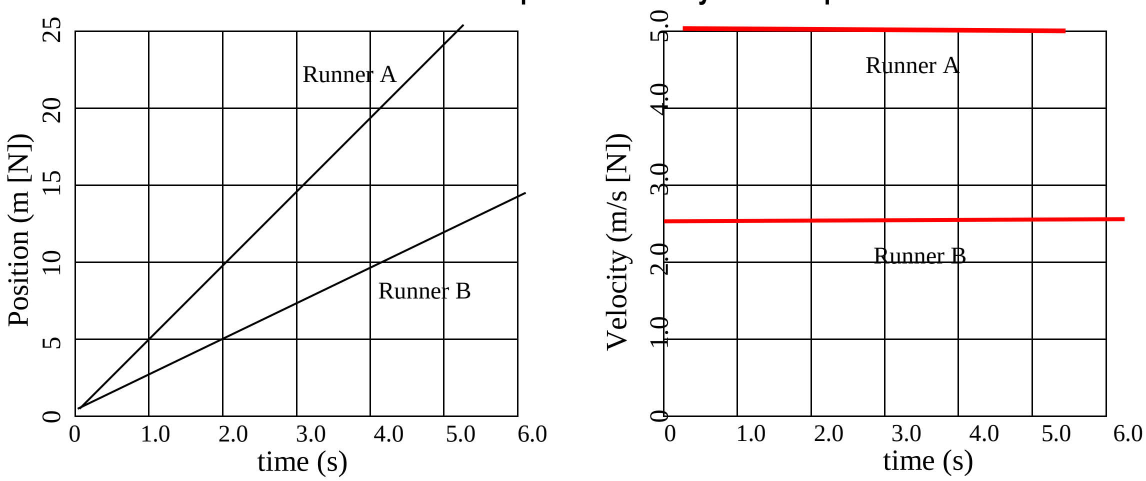
On a **position-time** ($\vec{d} - t$) graph,

1. the **slope** of the graph represents ___velocity_____________.

On a **velocity-time** ($\vec{v} - t$) graph,

2. the **slope** of the graph represents ____acceleration________.
3. the **area under** the graph represents __displacement_______.

Position-Time Graphs and Velocity-Time Graphs



1. What is the **slope** of the **position-time** graph for Runner A?

   5.0 m/s [N]

2. What is the **slope** of the **position-time** graph for Runner B?

   2.5 m/s [N]

3. What is the **displacement** (change in position) of Runner A after 4 s?

   20 m [N]

4. What is the **displacement** of Runner B after 6 s?

   15 m [N]

5. What is the **area** under the **velocity-time** curve for Runner A from 0 to 4 s?

   5.0 m/s [N] x 4 s = 20.0 m [N]

6. What is the **area** under the **velocity-time** curve for Runner B from 0 to 6 s?

   2.5 m/s [N] x 6 s = 15.0 m [N]

7. What is the **slope** of the velocity-time curve for Runner A?

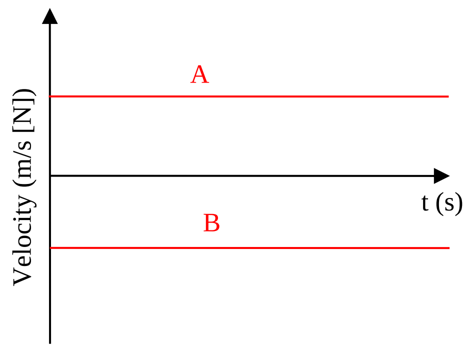
   0 m/s/s (0 m/s^2)

8. What is the **slope** of the velocity-time curve for Runner B?

   0 m/s/s (0 m/s^2)

Sketching Velocity-Time Graphs:

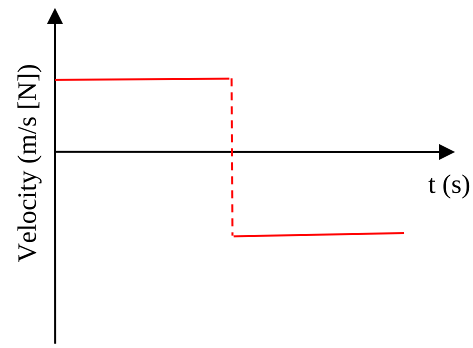
Graph A



Runner A runs at a constant velocity of 2 m/s [N], while Runner B runs at a constant velocity of 2 m/s [S] for 4 s.

What is Runner A's displacement after 4 s?
2m/s [N] x 4 s = 8 m [N]

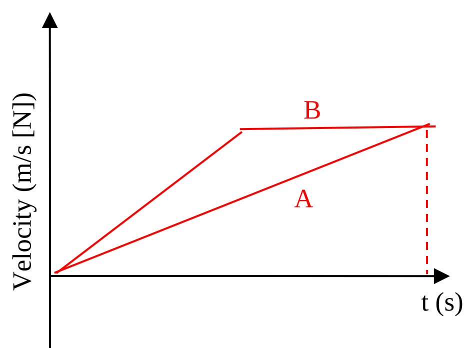
Graph B



A runner runs at a constant velocity of 2 m/s [N] for 2 s, and then instantaneously changes direction and runs 2 m/s [S] for another 2 s.

What is the runner's displacement after 4 s?
2 m/s [N] x 2 s + (-2 m/s [N] x 2 s) = 0 m

Graph C



Starting from rest, Bicycle A accelerates smoothly to 5 m/s [N] in 10 s. Starting from rest, Bicycle B accelerates smoothly to 5 m/s [N] in 5 s, and then continues for another 5 s at constant velocity.

What is Bicycle A's displacement?

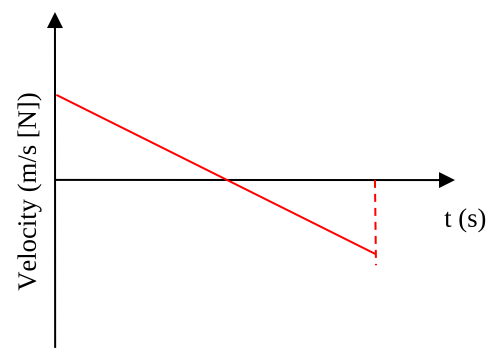
0.5 x 5 m/s [N] x 10 s = 25 m [N]

What is Bicycle B's displacement?

0.5 x 5 m/s [N] x 5 s + 5 m/s [N] x 5 s = 37.5 m [N]

If they both have the same starting position, who is ahead after 10 s? Bicycle B

Graph D



A lab cart is pushed so that it coasts up an inclined plane, starting at 5 m/s [N], and then it rolls back down the plane.

What can you say about the area between the graph and the time axis when the lab cart rolls back down to its original position?

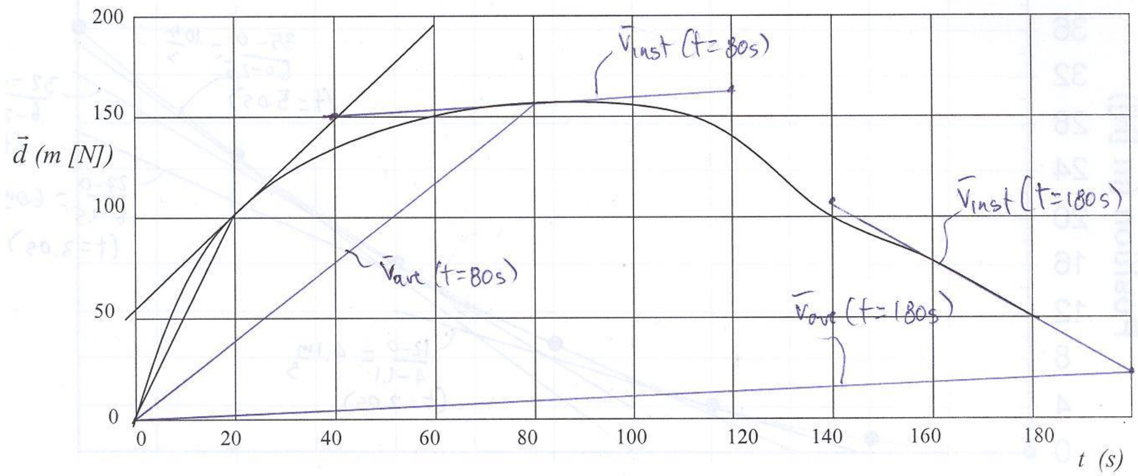
Area (rolling down) must be equal to the area (rolling up), so total area = 0 since displacement must be 0

SPH3U: Velocity Time Graphs

Answers: (0) 6 m/s [S], 24 m/s [S], 0, 12 m/s [N], (1) 30 m[S], (2) 210 m[S], 3. 45 m [N], 4. 390 m, 5. 13 m/s, 6. 300 m [S], 10.0 m/s[S], 8. 20 – 27.5 s, 9. a) 5 - 10s, 10 - 15s, 25 – 27.5s , b) 20 - 25s , c) 0 – 25 s , d) 25 - 30 s

Finding Instantaneous and Average Velocity from Position-Time Graphs

Consider the following position-time graph for a scooter:



Over the course of the **entire trip**, the scooter's motion is **non-uniform** (not constant in velocity – the speed and/or direction change) because the graph is not straight.

Instantaneous Velocity: the velocity at a **specific point** in time, calculated by finding the **slope of a <u>tangent line</u> to the curve (graph) at that point.**
A **tangent line** is a straight line which "touches" the curve only at the point of interest, and does not intersect it.

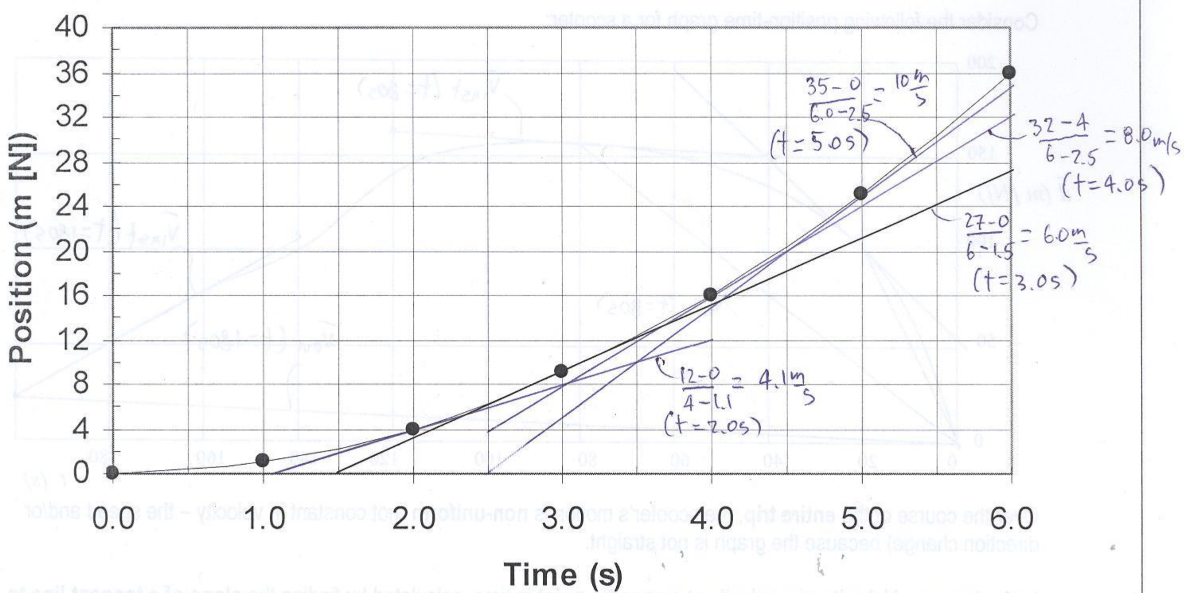
Average Velocity: displacement divided by the time required to complete that displacement; **ignores the actual path** travelled; calculated by finding **the slope of a <u>secant line</u> connecting the starting position and the end position**.
A **secant line** is a straight line which intersects two points on a curve.

$\vec{v}_{ave} = \frac{\Delta\vec{d}}{\Delta t} = \frac{\vec{d}_2 - \vec{d}_1}{t_2 - t_1}$, where Δd is the displacement (change in position), and Δt is the change in time

Worked Examples from the Graph:
A tangent line and secant line for t = 20 s have been drawn for you, and sample calculations for instantaneous and average velocity are shown. Find the instantaneous and average velocities for t = 80 s and t = 180s by drawing tangent and secant lines.

Timepoint (s)	Instantaneous Velocity	Average Velocity (from t = 0 s)
t = 20 s	$\vec{v}_{inst} = \frac{195-50}{60-0} = 2.4$ m/s [N]	$\vec{v}_{ave} = \frac{100-0}{20-0} = 5$ m/s [N]
t = 80 s	$\vec{v}_{inst} = \frac{160-150}{120-40} = 0.125$ m/s [N]	$\vec{v}_{ave} = \frac{155-0}{80-0} = 1.9$ m/s [N]
t = 180 s	$\vec{v}_{inst} = \frac{25-110}{200-140} = -1.4$ m/s [N]	$\vec{v}_{ave} = \frac{25-0}{200-0} = 0.125$ m/s [N]

SPH3U: Position-Time Graphs, Instantaneous Velocity, and Acceleration



Draw tangents on the position-time graph for at least 4 time points, calculate the slopes of these tangents to find the instantaneous velocities, plot them on a velocity-time graph, and draw a best-fit straight line.

What is the **slope** of your velocity-time graph? What is the **area** under your velocity-time graph from 0 to 6 s? What is the acceleration? What do you notice about the displacement from 0 to 6 s?