Acceleration

Acceleration is $\frac{\text{change in velocity}}{\text{change in time}} = \frac{\Delta v}{\Delta t}$

Example Problems

1. A sprinter starts from rest and reaches a speed of 12m/s in 4.25 s. Find her acceleration.

$$a = \frac{\Delta v}{\Delta t} = \frac{12\ m/s}{4.25\ sec} = 2.8\ m/s^2$$

2. A car starts from rest and accelerates at 15m/s^2 for 3.0 seconds. What is its top speed?

$$a = \frac{\Delta v}{\Delta t} \rightarrow at = v$$

$$\left(\frac{15\ m}{s^2}\right)(3.0\ sec) = 45\ m/s$$

3. If a snowboarder is traveling at 8.0m/s how long will it take her to reach 36.0 m/s if she can accelerate at a rate of 3.5 m/s^2

$$\Delta v = 36 - 8 = 28\ m/s$$

$$t = \frac{v}{a} \rightarrow \frac{28\ m/s}{3.5\ m/s^2} \qquad \frac{28}{3.5}\ \frac{m}{s} \times \frac{s^2}{m}$$

$$= 8.0\ sec$$

All vectors include direction. Generally, up or to the right is __+__ down or to the left is __−__.

Where it makes sense "forward" is generally __+__ and "backwards" in normally __−__.

	Velocity	Acceleration
A car sitting at a stop light hits the gas	+	+
From rest you back out of your driveway	−	−
A car slows to a stop	+	−
You drop a rock off a cliff	−	−
You throw a rock straight up	+	−

Determine the signs (positive or negative) of velocity and acceleration in each of the following

1. A stop light turns green and a car hits the gas.

2. A car backs out of a driveway.

3. A car slows to a stop.

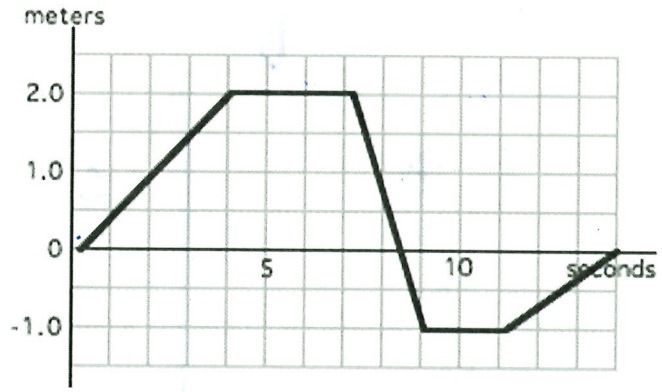
4. A rock is dropped from a cliff.

5. A rock is thrown straight up.

Velocity – Time Graphs

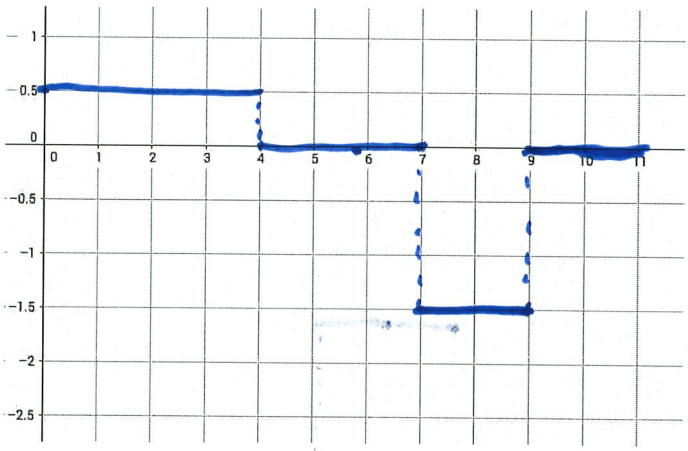
Interval	Velocity
0 – 4 s	$\frac{2m}{4s} = 0.5\ m/s$
4 – 7 s	0
7 – 9 s	$\frac{-3m}{2s} = -1.5\ m/s$
9 – 11 s	0
11 – 14 s	$\frac{1m}{3s} = 0.33\ m/s$

Position - Time Graph



Use the velocities to generate a velocity vs time graph.

Velocity-Time Graph

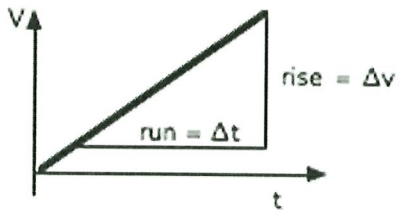


A horizontal line on a V-T graph represents a constant velocity.

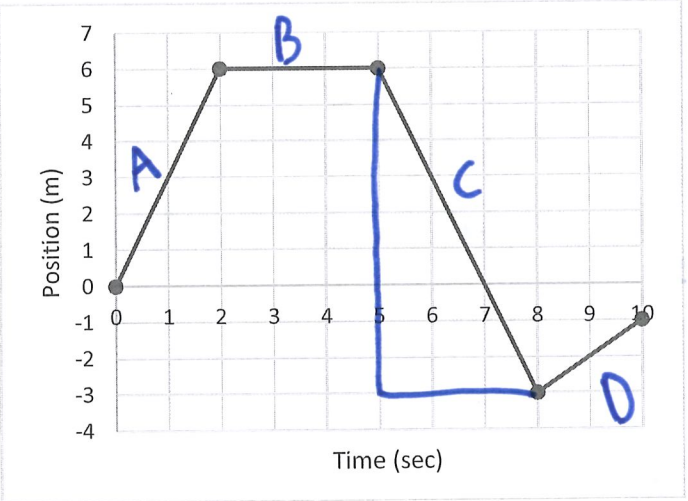
Anything above the time axis means motion in the positive direction, below the time axis means motion in the negative direction, and on the time axis means zero velocity.

A vertical line represents an instantaneous change in velocity

Acceleration = slope of v-t graph



Example: Convert the following position time graph into a velocity time graph.

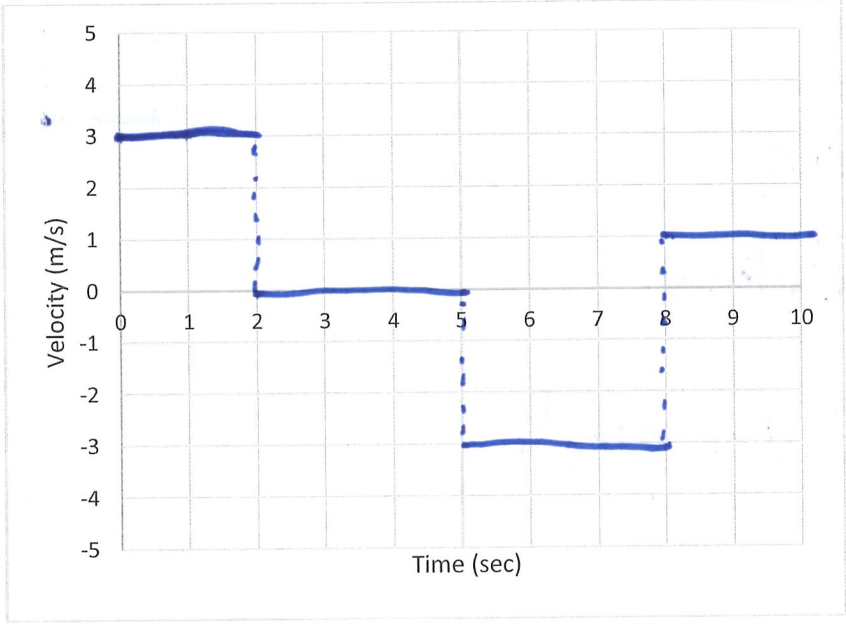


A: $\frac{6m}{2sec} = 3m/s$

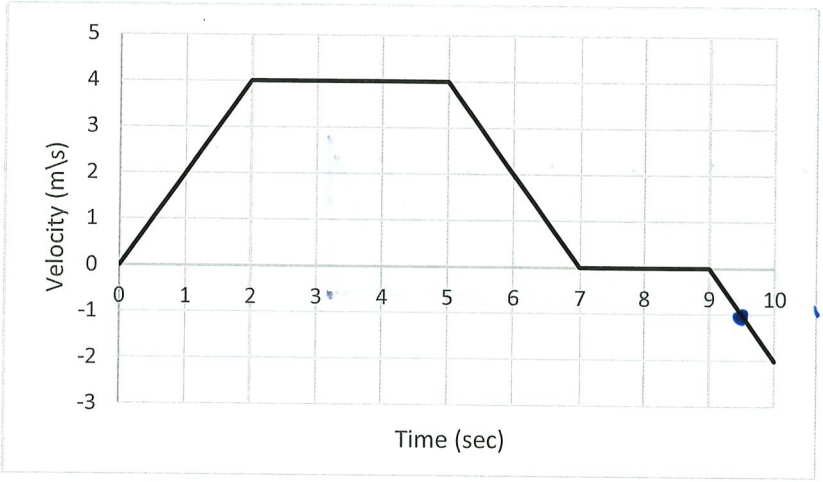
B: 0

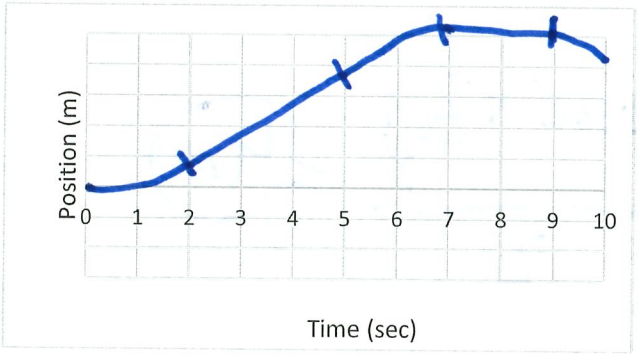
C: $\frac{-9m}{3s} = -3m/s$

D: $\frac{2m}{2s} = 1m/s$



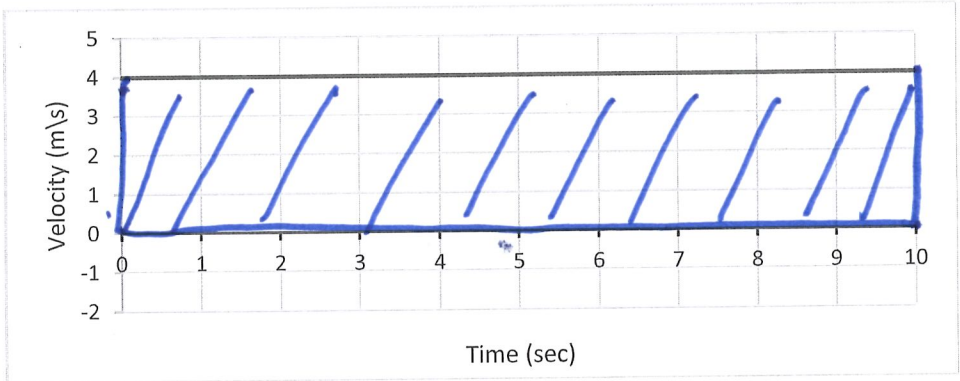
Example:



When is the object moving in the positive direction? 0-7 sec	When is the object moving in the negative direction? 9-10 sec
When is the object stationary? 7-9 sec	When is the object's acceleration positive? 0-2 sec
When is the object's acceleration negative? 5-7, 9-10	What is the object's acceleration from t=0 to t=2? $a = \frac{\Delta v}{\Delta t} = \frac{4\,m/s}{2\,sec} = 2\,m/s^2$
What is the object's velocity between t=2 and t=5? 4 m/s	What is the object's instantaneous velocity at t=9.5? -1 m/s
Sketch a position time graph for this motion	

Displacement from a Velocity-Time Graph

1. Consider the following graph

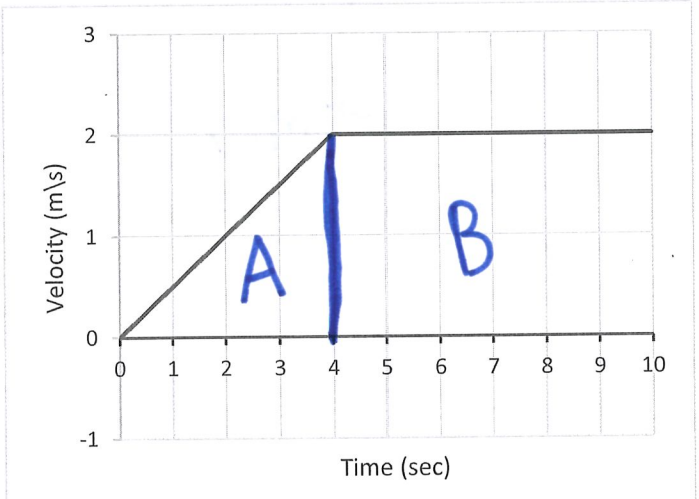


a. Describe the motion: Constant velocity of 4m/s

b. The displacement during the 10 seconds shown is $4\text{m/s} \times 10\text{sec} = 40\text{m}$

Displacement = Area between x-axis and line

2. Determine the displacement during the 10 seconds shown



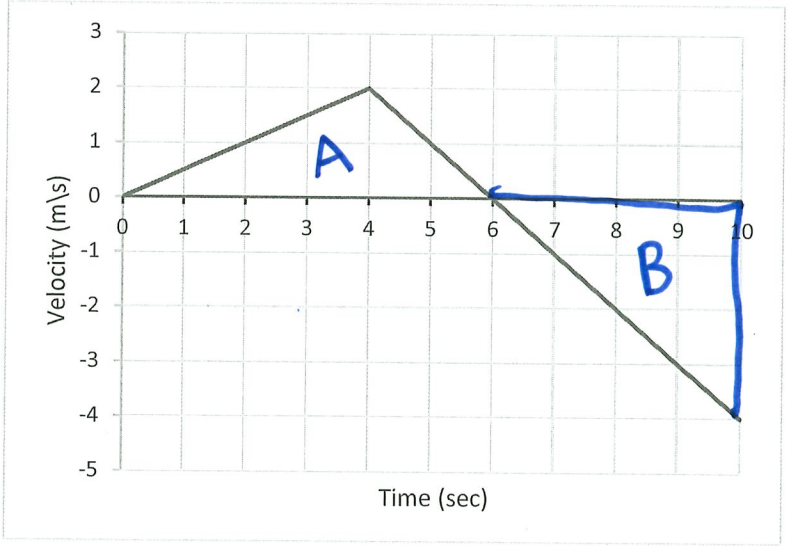
Area of triangle $= \frac{bh}{2}$

A: $\frac{4\text{sec} \times \frac{2\text{m}}{\text{s}}}{2} = 4\text{m}$

B: $6\,\text{sec} \times \frac{2\text{m}}{\text{sec}} = 12\text{m}$

Total displacement $= 16\text{m}$

3. Determine the displacement during the 10 seconds shown



$$A: \frac{6\,\text{sec} \times \frac{2\,\text{m}}{\text{sec}}}{2} = 6\,\text{m}$$

$$B: \frac{4\,\text{sec} \times \frac{-4\,\text{m}}{\text{s}}}{2} = -8\,\text{m}$$

$$\text{Total: } 6 + -8 = -2\,\text{m}$$

Kinematics Formulas

When dealing with objects moving at a **constant velocity**, we can determine

Displacement:

Velocity:

Time:

Consider an object that starts out moving a certain velocity, then accelerates to go faster.

We need to differentiate 3 different velocity measures.

$v_0 =$

$v_f =$

$v_{avg} =$

When dealing with objects moving with a **constant acceleration,** we can use the following formulas.
