Conceptual Questions:

1. What is the difference between average and instantaneous velocity? How can you calculate either one?

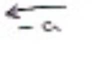
An average velocity is obviously an average value taken over a certain amount of time. An instantaneous velocity would be a specific value taken at one specific point in time.

Average velocity $\bar{v} = \frac{\text{displacement}}{\text{time}} = \frac{\Delta x}{\Delta t}$

Instantaneous velocity $v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$

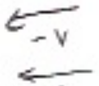
* Velocity taken within a very small amount of time.

2. What motion do you get with a positive velocity and a negative acceleration?



The object would start out moving forward in a positive direction, but it would slow down, stop, and then begin to move in a negative direction gradually faster and faster

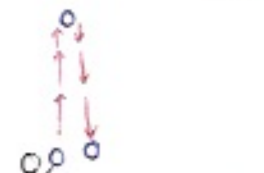
3. What motion do you get with a negative velocity and a negative acceleration?



The object would be moving in a negative direction, gradually faster and faster.

4. Consider, when you throw an object into the air and it reaches its highest point, what kind of velocity does it have (positive, negative, or zero)? What kind of acceleration does it have (positive, negative, or zero)?

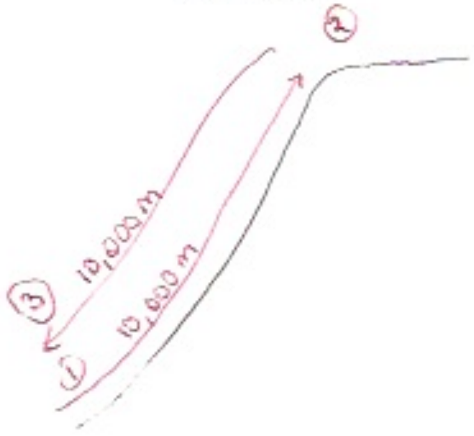
At the ball's highest point:



Velocity = 0 m/s
(ball is about to change directions)

acceleration = $-9.8\,m/s^2$
(gravity is dictating the ball's movements and the acceleration of gravity never stops working.)

A cyclist bikes up a mountain (10.0 km) with an average speed of 2.78 m/s. He rests at the top of the mountain for 5.00 minutes, then bikes down the mountain (10.0 km) with an average speed of 5.56 m/s. What is the cyclist's average speed for the entire trip? Express your answer in SI Units.



Entire Trip

Part ① Bikes 10.0 km = 10,000 m with an average speed of 2.78 m/s

Average Speed = $\frac{\text{Distance}}{\text{time}}$

$2.78 = \frac{10,000}{\text{time}}$

$2.78 \cdot \text{time} = 10,000$

$\text{time} = \frac{10,000}{2.78}$

time = 3597 s

Part 2

Rests for 5.00 minutes

no speed

no distance

time = (5.00)(60) = 300 s

Part 3 Bikes 10.0 km = 10,000 m with an average speed = 5.56 m/s

Average Speed = $\frac{\text{Distance}}{\text{time}}$

$5.56 = \frac{10,000}{\text{time}}$

$5.56 \cdot \text{time} = 10,000$

$\text{time} = \frac{10,000}{5.56}$

time = 1799 s

For the Entire Trip

Avg. Speed = $\frac{\text{total distance}}{\text{total time}}$

Avg. Speed = $\frac{10,000 + 0 + 10,000}{3597 + 300 + 1799}$

Avg. Speed = $\frac{20,000}{5696}$

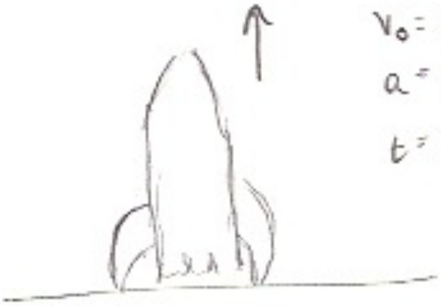
$\boxed{\text{Avg. Speed} = 3.51 \text{ m/s}}$

A rocket moves upward, starting from rest with an acceleration of 13.2 m/s² for a time of 3.98 s.

A. How far does the rocket travel during this time?

B. What is the final velocity of the rocket after 3.98 s?

C. After the 3.98 s, the engines shut off. The rocket with its velocity from part B, begins to slow down due to gravity. How much higher does the rocket rise before it has a velocity of 0 m/s?



$v_0 = 0 \text{ m/s}$

$a = 13.2 \text{ m/s}^2$

$t = 3.98 \text{ s}$

A.) $y = ?$

$y = v_0 t + \frac{1}{2} a t^2$

$y = (0)\cdot t + \frac{1}{2}(13.2)(3.98)^2$

$y = 0 + 105$

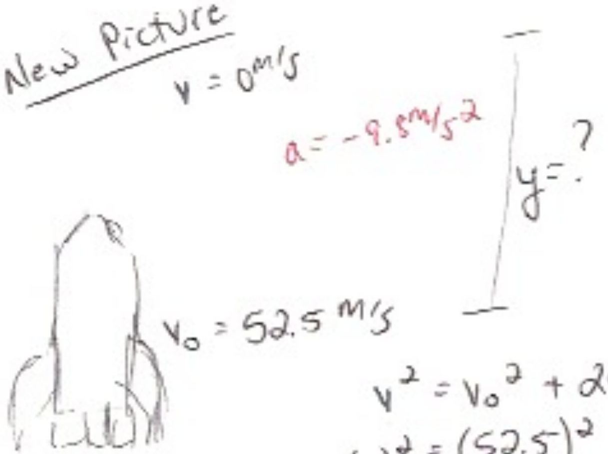
$\boxed{y = 105 \text{ m}}$

B.) $v = ?$

$v = v_0 + at$

$v = 0 + (13.2)(3.98)$

$\boxed{v = 52.5 \text{ m/s}}$



C.) After the rocket has moved 105 m and has a velocity of 52.5 m/s, the engines shut off, allowing gravity (a = -9.8 m/s²) to slow the rocket down to a velocity of zero

$v^2 = v_0^2 + 2ay$

$(0)^2 = (52.5)^2 + 2(-9.8)(y)$

$0 = 2756. - 19.6y$

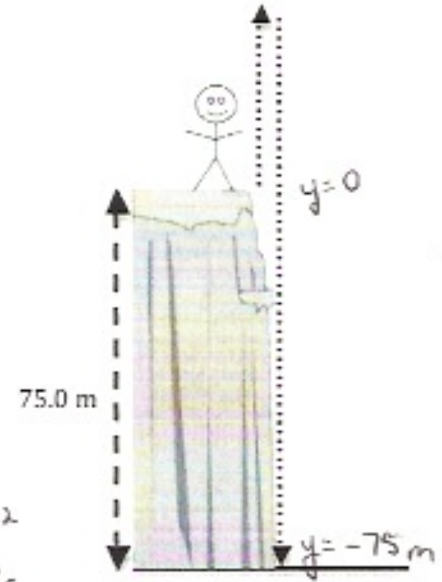
$-2756 = -19.6y$

$y = \frac{-2756}{-19.6}$ $\boxed{y = 141 \text{ m}}$

A stone is thrown vertically upward with an initial velocity of 12.0 m/s on the edge of a cliff that is 75.0 m high.

A. How long does it take the stone to reach the bottom of the cliff?

B. What is the final velocity of the stone just before it hits the ground?



A.)

$y = -75.0\ m$

$a = -9.8\ m/s^2$

$v_0 = 12.0\ m/s$

$t = ?$

$y = v_0 t + \frac{1}{2} a t^2$

$-75 = 12 \cdot t + \frac{1}{2}(-9.8)\, t^2$

$-75 = 12 \cdot t - 4.9 t^2$

QUADRATIC

$4.9t^2 - 12 \cdot t - 75 = 0$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{12 \pm \sqrt{(-12)^2 - 4(4.9)(-75)}}{2(4.9)}$$

$$\frac{12 \pm \sqrt{144 + 1470}}{9.8}$$

$$\frac{12 \pm \sqrt{1614}}{9.8}$$

$$\frac{12 \pm 40.3}{9.8}$$

2 possible roots

① $t = \frac{12 + 40.3}{9.8}$

$\boxed{t = 5.34\ s}$

② $t = \frac{12 - 40.3}{9.8}$

$t = \cancel{-2.88}\ s$

* time is not negative

B.)

$y = -75.0\ m$

$a = -9.8\ m/s^2$

$v_0 = 12.0\ m/s$

$v = ?$

$v^2 = v_0^2 + 2ay$

$v^2 = (12)^2 + (2)(-9.8)(-75)$

$v^2 = 144 + 1470$

$v^2 = 1614$

$v = \sqrt{1614}$

$v = \pm 40.2\ m/s$

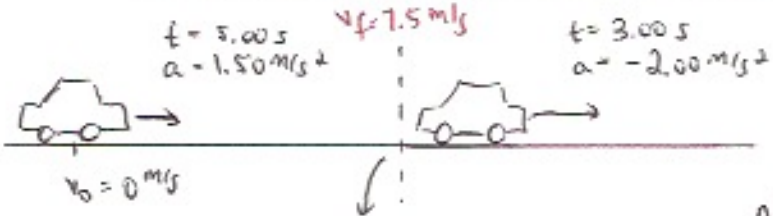
* since we are moving downward

$\boxed{v = -40.2\ m/s}$

A car moves forward, starting from rest, and travels for 5.00 s with an acceleration of 1.50 m/s². The driver then applies the brakes, which provide an acceleration of -2.00 m/s². The brakes are applied for 3.00 s.

A. What is the maximum positive velocity the car attained?

B. What is the total displacement through the entire 8.00 s?



$v = ?$

at the end of the first 5.00 s, this will be the initial velocity of the t = 3.00 s interval.

A.) $v = ?$

$v_0 = 0\ m/s$

$a = 1.50\ m/s^2$

$t = 5.00\ s$

$$v = v_0 + at$$

$$v = 0 + (1.50)(5.00)$$

$$\boxed{v = 7.5\ m/s}$$

B.) displacement from both segments.

Segment 1

$v_0 = 0\ m/s$

$a = 1.50\ m/s^2$

$t = 5.00\ s$

$x = ?$

$$x = v_0 t + \tfrac{1}{2} a t^2$$

$$x = (0)(5.00) + \tfrac{1}{2}(1.50)(5.00)^2$$

$$x = 0 + 18.75$$

$$\boxed{x = 18.75\ m}$$

Total Displacement

$$\boxed{18.75 + 13.5 = 32.25\ m}$$

Segment 2

$a = -2.00\ m/s^2$

$t = 3.00\ s$

$v_0 = v_f$ from the first segment $= 7.5\ m/s$

$x = ?$

$$x = v_0 t + \tfrac{1}{2} a t^2$$

$$x = 7.5(3.00) + \tfrac{1}{2}(-2.00)(3.00)^2$$

$$x = 22.5 + (-9)$$

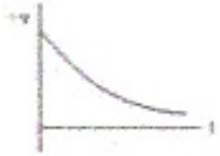
$$\boxed{x = 13.5\ m}$$

All graphs shown below are **VELOCITY VS TIME** graphs. Please identify the following:

A. Which graphs show positive velocities?
B. Which graphs show negative velocities?
C. Which graphs show positive accelerations?
D. Which graphs show negative accelerations?

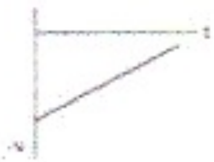
A

B

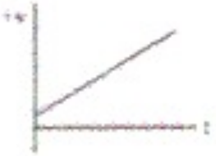


C

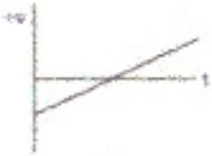
D



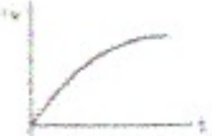
E



F



G



H

* It is important to note that these are velocity graphs.

A.) Since the line itself is showing velocity, Graphs B, C, F, H, and part of G all have positive velocities because the line of the graph is above the x-axis.

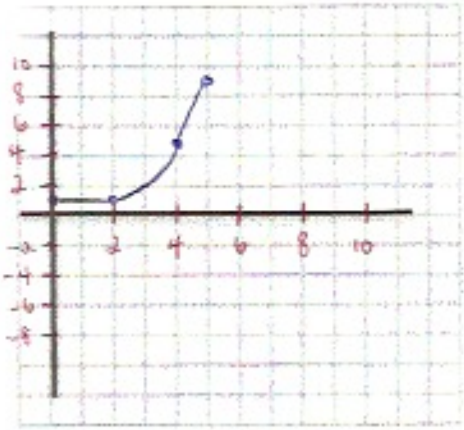
B) Since the line itself is showing velocity, Graphs A, D, E, and part of G all have negative velocities because the line of the graph is below the x-axis

c.) Acceleration is based on the slope of a velocity graph. So graphs E, F, G, and H all have lines that slope upwards.

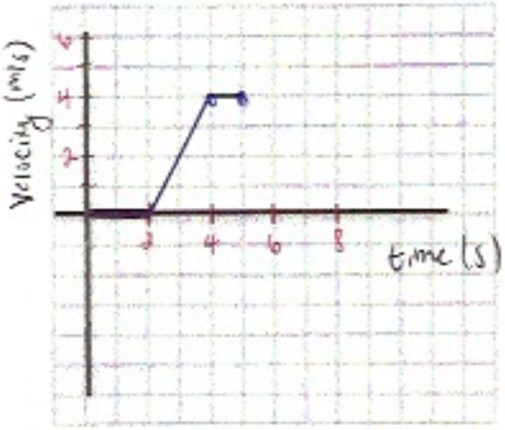
D.) Again, because acceleration is based on the slope of a velocity graph, Graphs A, B, C, and D all have lines that slope downwards.

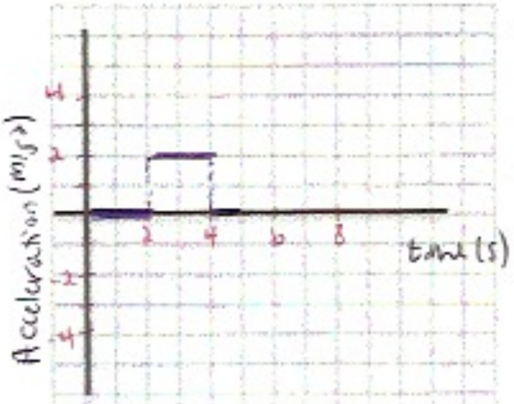
Sketch the position vs. time graph for an object that does the following.

A. The object begins at a position x = 1.0 m and remains stationary for the first 2 seconds.
B. The object then accelerates forward to a position x = 5.0 m in 2 more seconds.
C. The object then continues forward with a constant velocity to a position of x = 9.0 m in 1 more seconds.



Based on the position graph sketched in question 10, please sketch the velocity and acceleration vs. time graphs.





The only acceleration is the positive acceleration from t: 2.0 s → t: 4.0 s

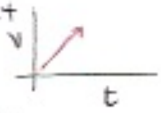
So we take the Slope of the velocity graph

$a = \frac{\Delta v}{\Delta t} = \frac{4-0}{4-2} = \frac{4}{2}$

$a = 2 m/s^2$

① During the first 2.0 s, the object is stationary. So $\bar{v} = 0 m/s$

② During the next 2.0 s, the object undergoes a positive acceleration which will create an upward sloping line on our velocity graph. The area under our velocity graph shows the change in the object's position during that time (2.0 s) The area under the curve will be the area of a triangle.



Area under the velocity curve - Δx

$\frac{1}{2} b h = 4$ → object moved 4.0m

b = base (so the acceleration happened in 2.0 s)

$\frac{1}{2}(2) h = 4$

$h = 4$

③ The velocity is the slope of the position graph for the last second.

$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{9-5}{5-4} = \frac{4}{1} = 4 m/s$