Lesson 5

Linear Motion

We covered how to "see", "draw", and "calculate" addition of force vectors in the previous lectures. This is because we want to connect vectors with the next concept, linear motions. In this lecture, we want to learn definitions as well as their mathematical expressions before we do applications. Once again, definitions are very important and you should know those as your second nature (if you learn now, it makes 230 much easier to learn when you have to combine different concepts.).

Terms	Definition	Direct Mathematical Translation
Position		
Velocity		
Acceleration		

The key phrase to know the relations of those three terms is "the rate of". You learn this phrase as "slope of whatever the function at a certain point of x" = "differentiation of Y(x) W.R.T. (hereon with respect to) in the first semester calculus. Applying this to physics, whenever you see/think "the rate of", you are going to differentiate the given function W.R.T. a certain variable ("time" in this case since all the functions are the function of time.) Once you can correctly remember their definitions, you can translate them in to mathematical expressions. This will enable you to derive other functions once one of three functions is given.

Example 1 – When "a" is constant: Gravitational Acceleration

a = -g (where "g" is the gravitational acceleration = 9.81 m/sec^2 on the earth's surface)

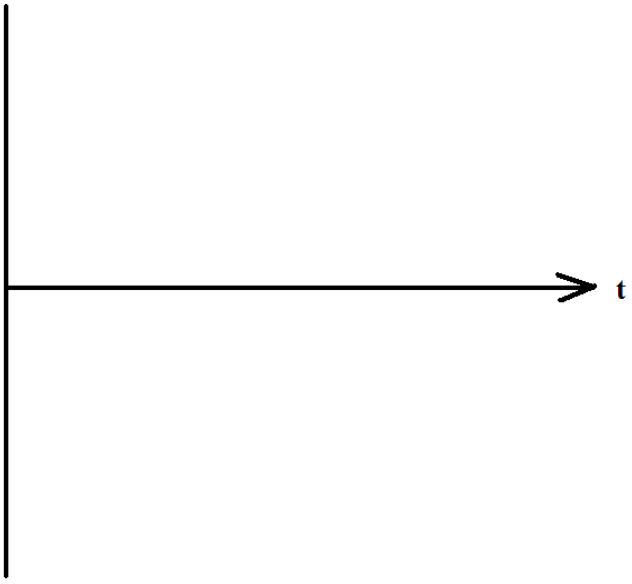
v =

y =

Let's graph these because we can learn so much from these graphs.

Graph a vs. t

On the graph you just drew, where is "change of velocity" indicated?



The next is to graph "velocity" vs. "time". However, I want you to notice that you need one more information before you can complete the graph. What is the missing information? How does it affect when you graph?

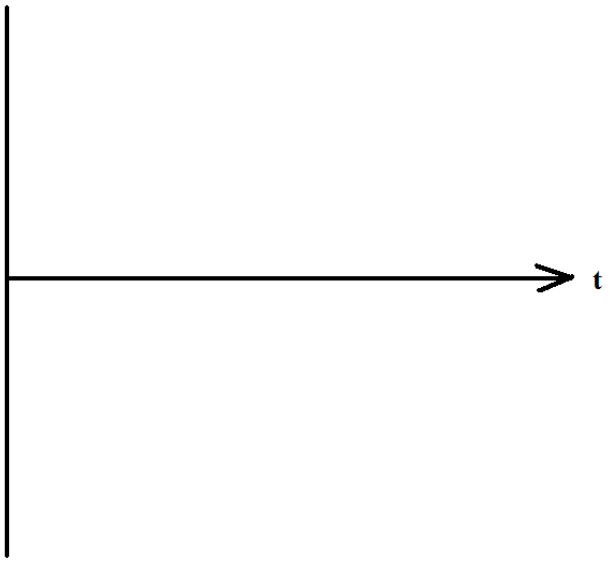
Graph v vs. t

If the graph starts above the time axis, what does this mean physically?

If the graph stars below the time axis, what does this mean physically?

How is "acceleration" presented in this graph?

How is "distance traveled" presented in this graph?



The next is to graph “position” vs. “time”. However, I want you to notice that you need one more information before you can complete the graph. What is the missing information? How does it affect when you graph?

Graph y vs. t

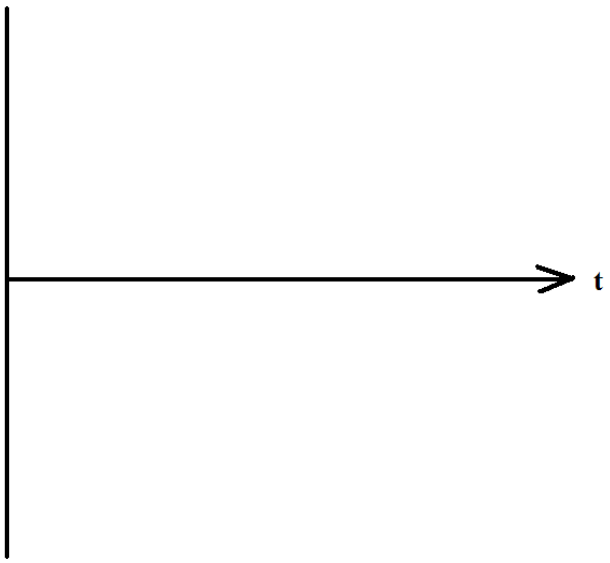
If the graph starts above the time axis, what does this mean physically?

If the graph stars below the time axis, what does this mean physically?

How is “acceleration” presented in this graph?

How is “velocity” presented in this graph

How is “distance traveled” presented in this graph?

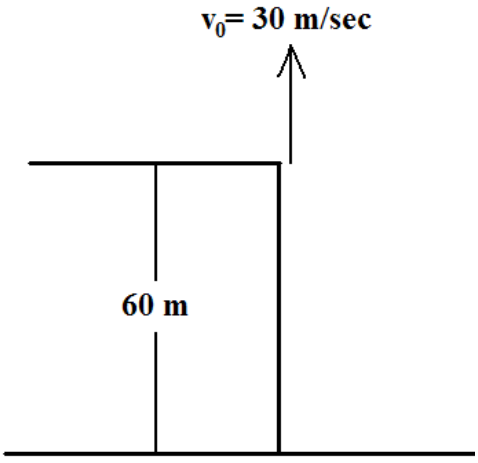


Typical questions using the gravitational acceleration are the following:

An object is ejected at 30 m/sec from the top of a 60m-cliff.

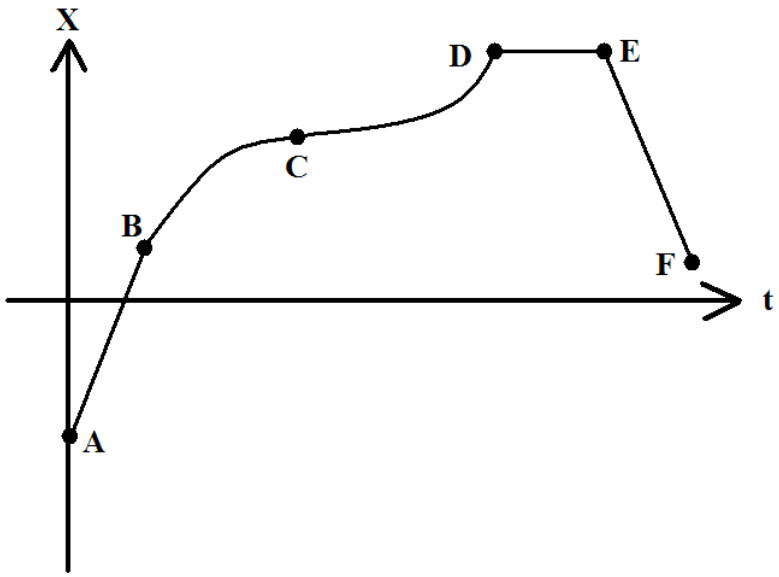
Calculate:

1. Maximum height
2. Velocity when it comes back to the initial position
3. Impact velocity when it hits the ground



Example 2

The graph of x vs. t is for a particle in straight line motion. Indicate whether v and a are +, 0, or – for those intervals



segment	v	a
AB		
BC		
CD		
DE		
EF		

Example 3

The velocity of a particle moving along the x axis is described by $v(t) = At^2 + Bt - 4$, where v(t) and t are in SI (standard) units.

(a) What are the units of A and B?

(b) Let A = 3 and B = 6. What are the accelerations of the particle when it is at x = 0 m (Given x_0 = 0m)?

Example 4

A ball is dropped from a height of 2.2 m and rebounds to a height of 1.9 m above the floor. Assume the ball was in contact with the floor for 96 ms (milliseconds). Determine the average acceleration (both magnitude and direction) of the ball during the contact with the floor.