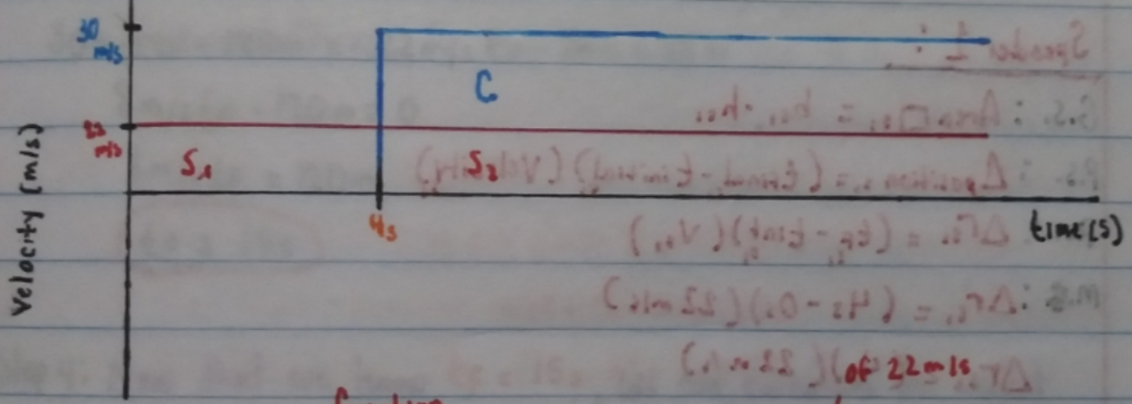
Feburary 5th, 2021: Cop and Speeder

A speeder is traveling with a constant velocity of 22 m/s. The speeder passes a cop that is standing still. Four seconds after the speeder passes the cop, the cop begins to travel @ 30 m/s. How long till the cop catches the speeder, and how far has the cop travel when he catches the speeder?

Step 1: First I drew a graph, and sense the units are velocity, I used a velocity-time graph. Velocity is a very robust method of showing where youre going, and how quickly.



* I drew Speeder's function with a constant velocity of 22 m/s for the entire duration of the scenario (from time = 0 to $Time_{Final}$), I drew the cop's function with a constant velocity of 30 m/s, but only from 4 s to T_{Final}. This is the case, because it took the cop 4 s to travel @ 30 m/s. I also separated speeder into S_1 and S_2. One before and after 4s.

Step 2: Now you would need a physics statement that describes the scenario effectively. Since we know that both the cop and speeder will be in the same position @ t_F, then we know that both displacements are equal. So the equation that means that:

$$\Delta r_{cop} = \Delta r_{S_{total}}$$

Step 2: So, now since we have a physics statement that describes this scenario, now we can start solving for T_{final}. In order to do that, we need to create a math statement from the graph. The most efficient way to do this is through the McClure method. This method includes:

- Geometry Statement
- Physic Statement (in word and variable format)
- Math Statement.

We are going to do this for all three sections on the graph.

Speeder 1:

G.S.: $Area\,\square_{s_1} = b_{s_1} \cdot h_{s_1}$

P.S.: $\Delta position_{s_1} = (t_{final_{s_1}} - t_{initial_{s_1}})(Velocity_{s_1})$

P.V.: $\Delta r_{s_1} = (t_{F_{s_1}} - t_{int_{s_1}})(V_{s_1})$

M.S.: $\Delta r_{s_1} = (4s - 0s)(22\,m/s)$

$\Delta r_{s_1} = (4s)(22\,m/s)$

$\Delta r_{s_1} = 88m$

Speeder 2

G.S.: $Area\,\square_{s_2} = b_{s_2} \cdot h_{s_2}$

P.S.: $\Delta position_{s_2} = (t_{final_{s_2}} - t_{initial_{s_2}})(Velocity_{s_2})$

P.V.: $\Delta r_{s_2} = (t_{F_{s_2}} - t_{int_{s_2}})(V_{s_2})$

M.S.: $\Delta r_{s_2} = (t_{F_{s_2}} - 4s)(22\,m/s)$

Cop

G.S.: $Area\,\square_{c} = b_c \cdot h_c$

P.S.: $\Delta position_c = (t_{final_c} - t_{init_c})(Velocity_c)$

P.V.: $\Delta r_c = (t_{F_c} - t_{int_c})(V_c)$

M.S.: $\Delta r_c = (t_{F_c} - 4s)(30\,m/s)$

Step 3: In order to solve for T_{Final} we would have to use the physics statement that described the scenario. This was:

$$\Delta r_{cop} = \Delta r_{speeder\ total}$$

Using this, we can solve for T_{Final}, because we know what the Δr_{cop}, and the $\Delta r_{s\ total}$ (which is $\Delta r_{s_1} + \Delta r_{s_2}$). All we need to do now is plug in for those variables.

$$\underline{\Delta r_{cop} = \Delta r_{speeder\ total}}$$

$$(t_F - 4s)(30\,m/s) = (t_F - 4s)(22\,m/s) + 88\,m$$

$$30\,m/s\,t_F - 120\,m = 22\,m/s\,t_F - 88\,m + 88\,m$$

$$8\,m/s\,t_F - 120\,m = 0$$

$$8\,m/s\,t_F = 120\,m$$

$$t_F = 15\,s$$

Step 4: Now that we know $t_F = 15s$, we can calculate the amount of time it took the cop to catch up to the speeder. We know that $\Delta t = t_{Final} - t_{Initial}$, so let's plug stuff in!

$$\Delta t = t_{Final} - t_{Initial}$$

$$\Delta t = 15s - 4s$$

$$\Delta t = 11s$$

So, we now know that it took the cop 11s in order to catch up to the speeder.

Step 5: Next we are going to find how far the cop traveled to reach the speeder aka Δr_{cop}, which is:

$$\Delta r_{cop} = (15_s - 4_s)(30\ m/s)$$

$$\Delta r_{cop} = (11_s)(30\ m/s)$$

$$\Delta r_{cop} = 330\ m$$

* So now we know that the cop traveled 330m before they caught up to the speeder.

Step 6: Now we are going to check to see if our t_{Final} is correct, by plugging all of our values into our physics statement that describes the scenario.

$$\Delta r_{cop} = \Delta r_{speeder\ total}$$

$$330m = (15_s - 4_s)(22\ m/s) + 88\ m$$

$$330m = (11_s)(22\ m/s) + 88\ m$$

$$330m = 242\ m + 88\ m$$

$$330\ m = 330\ m$$

* Hooray! It looks like our T_{Final} is correct! So to summarize:
- The cop took 11s to catch up to the speeder
- The cop traveled 330 m before catching the speeder
- T_{Final} was 15s

Journal: Feburary 8^{th}, 2021: Tipers Velocity and Acceleration

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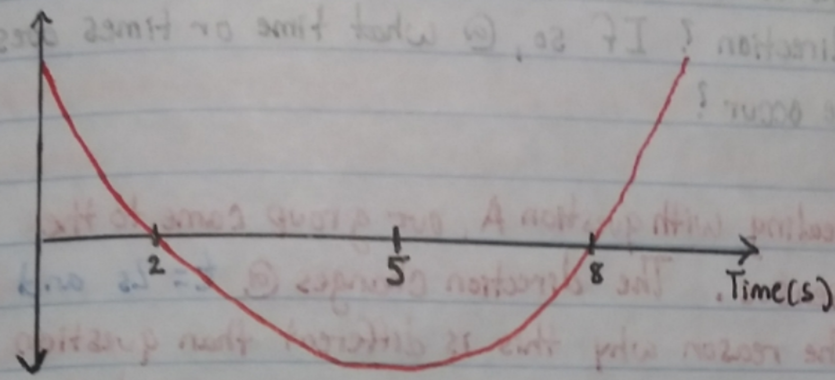

a.) If the vertical axis is position, does the object ever change direction? If so, at what time or times does this change in direction occur?

* When looking at this graph, I wrongfully assumed that the the direction change @ $t = 2s$ and @ $t = 8s$. This was not the case, because position does not have direction, velocity has direction. So, I would have been correct if this was a ~~posid~~ $v(t)$-graph, but this is an $r(t)$-graph. So, what can you infer on an $r(t)$-graph that gives you direction? Well velocity holds direction, and we know that the slope of an $r(t)$ graph is velocity, so the slope should tell us where direction changes. So where does slope change? At the vertex of the graph @ $t = 5$ seconds.

My group discussed how easily fooled one can be if you do not pay attention. Knowing how position and velocity are related will help a lot with a question like this.

b.) If the vertical axis is velocity, does the object ever change direction? If so, @ what time or times does this change occur?

* After dealing with question A, our group came to the same consensus. The direction changes @ t=2s and t=8s. The reason why this is different than question A is, because in question A, the slope represented the velocity. So if you wanted to see the direction of velocity to change, you'd have to see the slope change. In this case however, the velocity on a V(t)-graph is shown on the vertical-axis itself. So whenever the function crosses the time axis, the direction of velocity changes. This happens twice on the v(t)-graph, once @ t=2s and once @ t=8s.

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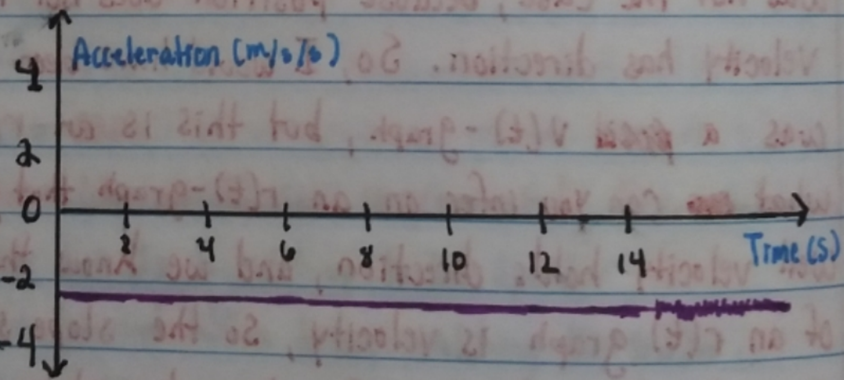


A student is given the acceleration vs. time for a motorcyclist traveling along a straight level stretch of road. The student states:

"This motorcyclist was slowing down during this period up to 14 seconds, because her acceleration was negative during this period."

What, if anything, is wrong with this student's contention?

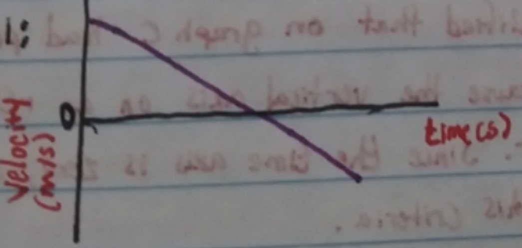
* When talking to my group, we discovered that this student's contention was incorrected, because what dictates whether an object speeds up or slows down is the direction for velocity. For the Gas and Brakes Lab, we discovered that:

Acceleration	Velocity	
(−)	(+)	= Slows down
(+)	(−)	= Slows down
(+)	(+)	= Speeds up
(−)	(−)	= Speeds up

Without the direction of velocity, it is impossible to know whether the object is speeding up or slowing down.

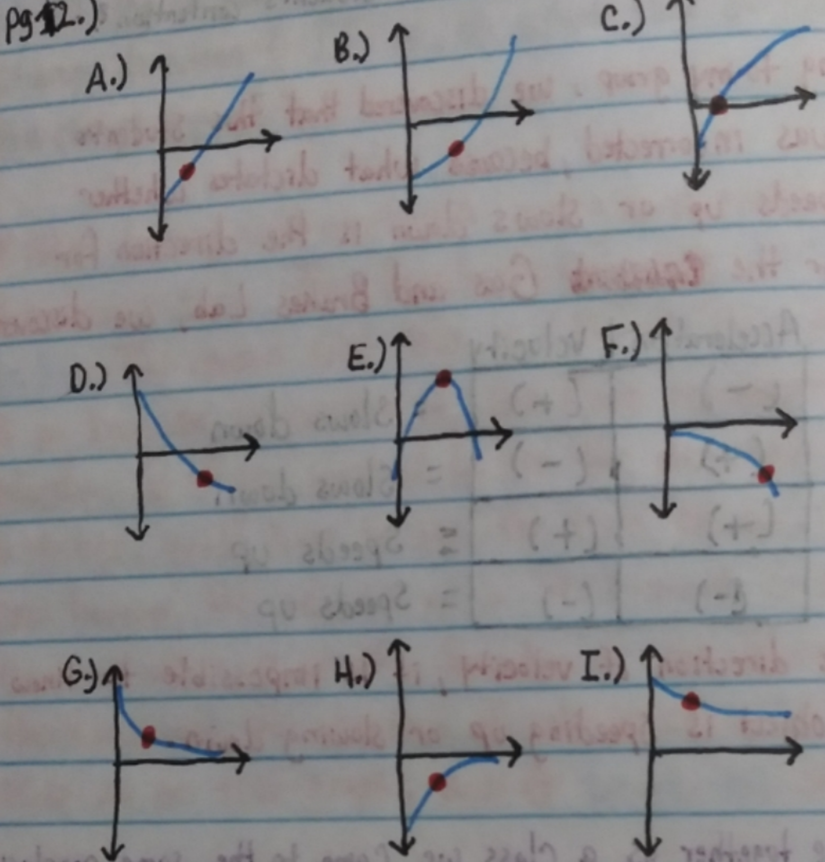
When we came together as a class we came to the same conclusion, we also gave an examples of when the acceleration is (−) and the object speeds up and slows down.

Example 1:



This proves graphically as well that generalizing that (−) acceleration means slowing down isn't true 100% of the time. Since it is not, it is not a good model of velocity / acceleration.

pg 12.)



a.) For which of these is the position zero @ the indicated point?

* Our group and I easily identified that on graph C. had position zero. We knew this, because the vertical axis on an r(t) graph shows you the value of r. Since the time axis is zero, C was the only graph to meet this criteria.

b.) For which of these is the position negative @ the indicated point?

* Our group and I agreed upon graphs A, B, D, F, and H having positions that are negative. For similar logical reasoning, we decided that any point below the time-axis has a (-) position, as the vertical axis tells you the value of r on an r(t)-graph.

c.) For which of these is the velocity zero @ the indicated point?

* Our group and I came to the conclusion that only graph E. had a velocity that was zero @ the indicated point. When working with r(t)-graphs, the only way you can figure out the value of velocity is look @ the slope of an r(t)-graph, but wait... graph E's slope constantly Changes, how can you possibly know velocity from E? Well the best way to find the slope of a curved line is to use the tangent line. If you find the slope of the tangent line @ all of these graphs, graph E. is the only one that has a zero slope.

d.) For which one of these is the velocity negative @ the indicated point?

* My group and I came to the conclusion that graphs D, F, G, and I met this criteria. Building on what was said before, the velocity is the slope of an r(t)-graph, so if you want to find a negative velocity on an r(t) graph, then the slope would have to be (-). ∴ If you make a tangent line @ every graph A-I, you'll see that only D, F, G and I have a (-) slope, therefore a (-) velocity @ the given point.

e.) For which one of these is the acceleration zero @ the indicated point?

* My group and I came to the conclusion that only graph A has an acceleration that is zero, because the slope for r(t) is linear, and if that's true then the v(t)-graph is constant and horizontal, if THAT's true then, the acceleration is zero. I originally thought E's was zero as well, but the r(t)-graph is not linear, yet the velocity is zero @ that point was going on? Well, that brings me into the next question perfectly.

f.) * My group and I came to the conclusion that graphs C, E, F, and H have accelerations that are (-), but for different reasons. So, I will address them separately:

1.) Graph C has a (-) acceleration, because as the object moves in the positive direction, it slows down. You can see this because the slope of the tangent line slowly becomes zero.

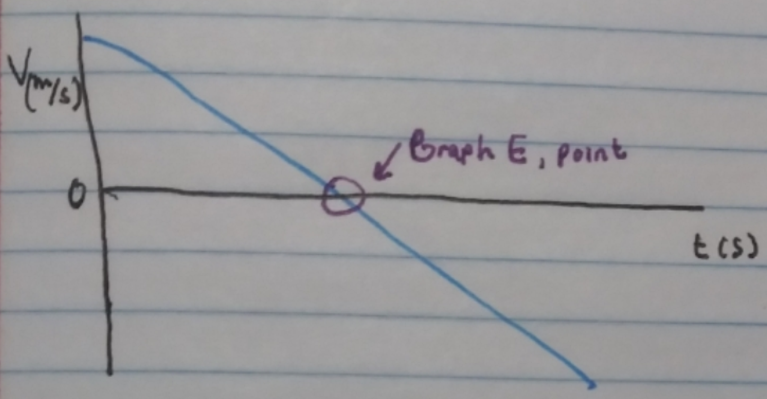
2.) Graph F has a (-) acceleration, because as the object moves in the (-) direction, the slope of the tangent line aka velocity, becomes larger.

3.) Graph H has a (-) acceleration, because as the object moves in the (+) direction, the slope of the tangent line aka velocity, becomes smaller, slowly going to zero.

E. is a special case. When we came together as a class we discussed why E's acceleration was (-). The hint was 1st, in the r(t) graph. Since, the r(t)-graph is curvy (or non-linear), there has to be an acceleration there. So how can we find out more info?. Well let's describe the motion then put it on a V(t)-graph, to see it better.

So, the object goes in the (+) direction, getting slower, stops for an instant, then goes in the (-) direction, getting faster.

This is the V(t)-graph:



You can clearly see that the acceleration is (-) due to the slope of the V(t)-graph being (-) as well. So ~~where~~ what does point E represent? It represents when the V(t) function crosses the time axis. At that point the velocity is 0, but the acceleration is negative.