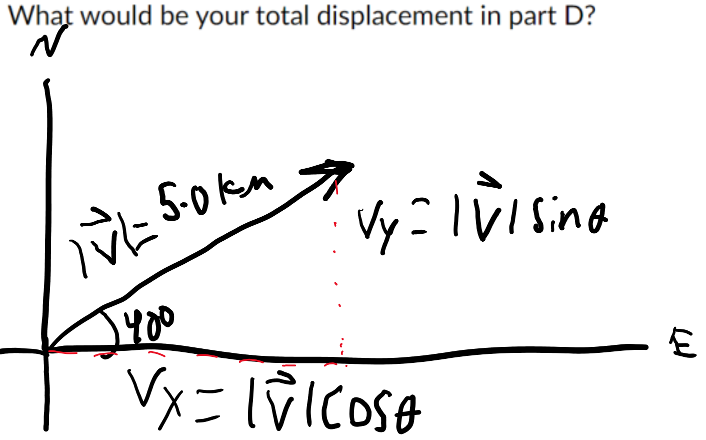
HW2

Monday, January 17, 2022 5:01 PM

1) Suppose that you are tracking zombies in the west desert, and you follow their trail straight across the salt flats to the Great Salt Lake. You begin your walk 5.0 km from the lake and travel in a direction 40 degrees north of east.

A. Make a sketch that shows this event.
B. What is your displacement to the East?
C. What is your displacement to the North?
D. If you instead first walked east, and then north, how far would you travel all together?
E. What would be your total displacement in part D?

A



B. Displacement to east is V_x

$V_x = 5.0\text{km} \cos(40) = \boxed{3.8\text{km}}$

C. Displacement to north is V_y

$V_y = 5.0 \sin(40) = \boxed{3.2\text{km}}$

D. Start going V_x distance then going V_y would result,

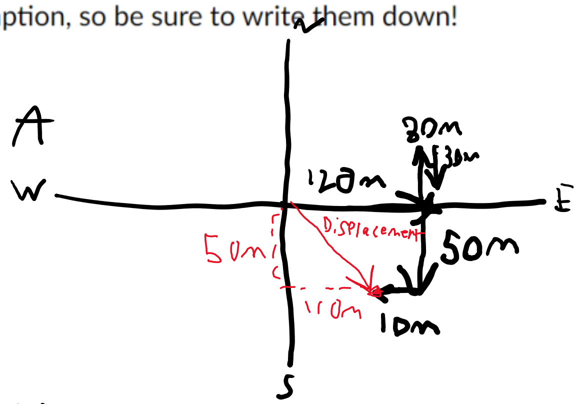
$V_x + V_y = 3.8\text{km} + 3.2\text{km} = \boxed{7\text{km}}$

E. Since the vectors do not travel against each other, the displacement is the same as distance, $\boxed{7\text{ km.}}$

2) A fox once stole one of Dr. Palen's ducks during the day. She chased the fox 120 m due east to the back of her property, then had to make a detour to the north 30 meters and back again to pass through a gate. She then proceeded to chase the fox 50 meters due south along the bank of the irrigation canal, where it turned due west and ran ten meters to hide behind a pile of gravel. That is where Dr. Palen scared the fox, which dropped the duck, and she got her duck back. (This is a true story!)

A. Make a sketch that shows the path of this chase.
B. What is Dr. Palen's total distance traveled?
C. What is Dr. Palen's displacement to the east?
D. What is Dr. Palen's displacement to the south?
E. What is Dr. Palen's total displacement?
F. Estimate: What is a reasonable amount of time for this chase to take? You will need to make at least one assumption, so be sure to write them down!

A



B. Total distance $= 120m + 30m + 30m + 50m + 10m = \boxed{240m}$

C. add the distances in the East and West directions.
$dx = 120m - 10m = \boxed{110m}$

D. add the distances in the north and South directions.
$dy = 30m - 30m - 50m = -50m$ from North
or $\boxed{50m \text{ to the South}}$

E. I am not sure if total displacement means to add up the displacements or to get the magnitude of the displacement vector. So I will get the magnitude.
$|\vec{d}| = \sqrt{100m^2 + 50m^2} = \boxed{111.8m}$

F. I assume that the average human runs at $2.9\frac{m}{s}$.
The reasonable amount of time for the chase would be the total distance traveled divided by the Avg running speed.

$$\frac{240m}{2.9\frac{m}{s}} = \boxed{82.8 \text{ Seconds}}$$

3) The Chelyabinsk meteorite hit the atmosphere in 2013, and it was magnificent. It exploded at an altitude of 23.5 km, causing a blast wave that destroyed some buildings and blew out a whole lot of windows, spreading glass everywhere in Chelyabinsk. The blast wave took 2 min and 30 sec to reach ground level.

A. How fast did the blast wave travel?

B. How does this speed compare to the speed of sound, which is 343 m/s, at the ground?

A.

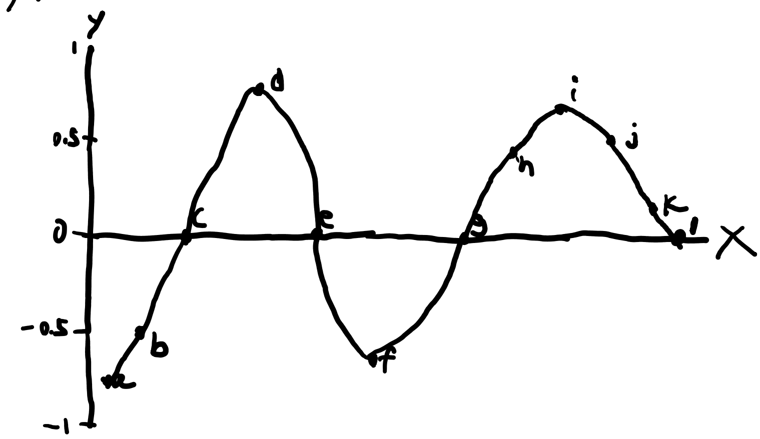
$$\frac{\text{distance}}{\text{Time}} = \text{rate}$$

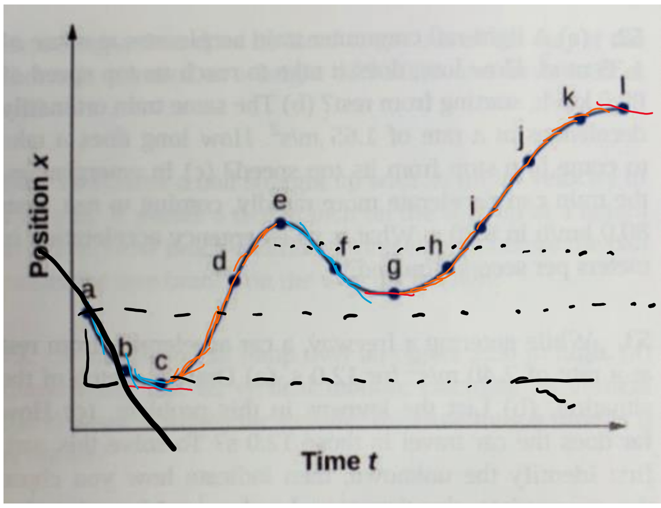
$$\boxed{\frac{23.5\,\text{km}}{150\,\text{s}} = 0.156\,\frac{\text{km}}{\text{s}} \text{ or } 156.6\,\frac{\text{m}}{\text{s}}}$$

B. This speed is slightly less than half the speed of sound at ground level.

4) Suppose that you have a position vs time graph, as shown. Sketch (A) a velocity vs time graph and (B) an acceleration vs time graph to match. This graph should be qualitative in the same way that the given graph is...there are no numbers involved. (Hint: recall that the velocity is the derivative (i.e. the slope) of the position function. So you could find the slope for each labeled point, and put it on a new graph to make a velocity vs time graph. Similarly, the acceleration is the derivative of the velocity function...)

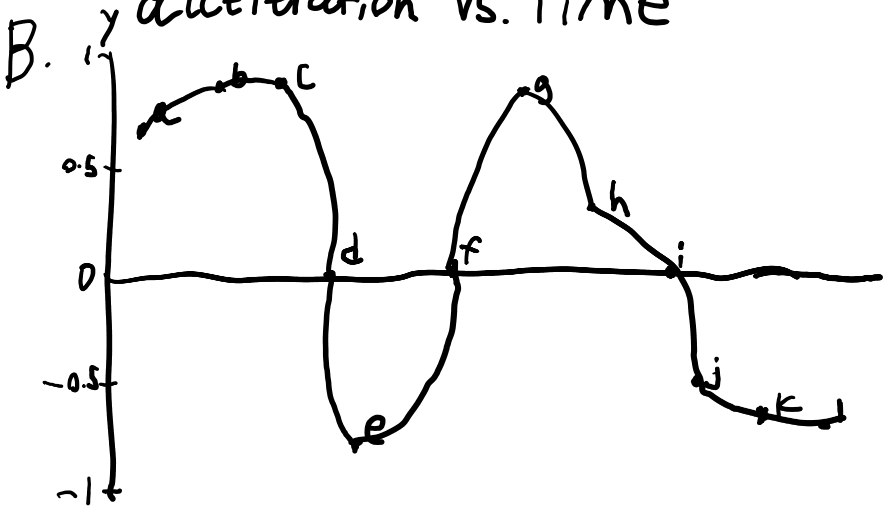
A. Velocity vs. time





Zeros
negative
Positive

B. acceleration Vs. Time



5) Every so often, somebody tries to get across the tracks in front of the Front Runner (our local commuter train). This almost always works out badly for them.

A. Suppose the Front Runner accelerates at a rate of 1.35 m/s^2 to its typical speed of 40 m/s. How long does it take to accelerate from rest when it leaves the station?
B. The train decelerates somewhat faster than it accelerates, at 1.65 m/s^2. How long does it take to decelerate to a stop at this typical rate?
C. In an emergency, the train can decelerate more quickly, coming to a rest in only 8.30 seconds. What is the Front Runner's emergency deceleration?
D. How far does the Front Runner travel while its makes an emergency stop?

A.

$$\frac{40\,m/s}{1.35\,m/s^2} = \boxed{29.63s}$$

B. $\bar{a} = \frac{\Delta V}{\Delta t} \Rightarrow \Delta t = \frac{\Delta V}{\bar{a}} = \frac{40\,m/s}{1.65\,m/s^2} = \boxed{24.24s}$

C. $\bar{a} = \frac{\Delta V}{\Delta t} = \frac{40\,m/s}{8.35s} = \boxed{4.82\,m/s^2}$

D. $S = S_0 + V_0 t + \frac{1}{2}at^2 = 0 + 40\,m/s \cdot 8.35s + \frac{1}{2}(-4.82\,m/s^2)(8.35s)^2$

$= \boxed{166m}$

6) Dr. Palen has a very old, very tall walnut tree on her farm. Most of the walnuts are too high too pick, but they do eventually fall down. Suppose a walnut drops from a branch that is 4 m in the air, and doesn't hit any other branches on the way down. How fast is the walnut moving right before it hits the ground?

$$v_f^2 = v_0^2 + 2a(s_f - s_0)$$

$$= 0^2 + 2(-9.8\,m/s^2)(0 - 4m) = 78.4\,m^2/s^2$$

$$v_f^2 = 78.4\,\frac{m^2}{s^2}$$

$$\boxed{v_f = 8.85\,m/s}$$

7) Ball bearings are made by letting spherical drops of molten metal fall inside a tall tower (called a "shot tower"). The bearings solidify as they fall.

A. If a bearing needs 4.0 s to solidify enough for impact, how high must the tower be?
B. What is the bearing's impact velocity?

A. $S = S_0 + v_0 t + \frac{1}{2} a t^2 = 0 + 0 \cdot 4s + \frac{1}{2}(9.8\,m/s^2)(4.0s)^2$

$= \boxed{78.2m}$

B. $V_f = V_0 + at = 9.8\,m/s^2 \cdot 4s = \boxed{39.2\,m/s}$

8) Suppose that it were actually possible to travel at the speed of light, and that relativity is not an issue.

A. How many days will it take a spaceship to accelerate to the speed of light ($3.0X10^8$ m/s) at an acceleration g? (This acceleration would make the astronauts feel right at home!)
B. How far will the spaceship travel during this time?
C. What fraction of a light year is your answer to part b?
D. Alpha Centauri is the nearest star system to the Sun, 4.3 light years from here. Assuming that the astronauts finish the journey traveling at the speed of light, how much total time will elapse on their journey?
E. Bonus, optional: Assume instead that they want to stop at Alpha Centauri. They need to slow down again before they get there, at the same acceleration, g. How long with the journey take in that case?

A. $$\frac{3\times10^8 \text{ m/s}}{9.8 \text{ m/s}^2} = 3.06\times10^7 \text{ s} = \boxed{354 \text{ days}}$$

*faster than I expected

B. $$V_f^2 = V_0^2 + 2aD$$

$$D = \frac{V_f^2}{V_0^2+2a} = \frac{(3\times10^8 \text{ m/s})^2}{0^2+2\cdot 9.8 \text{ m/s}^2} = \boxed{4.59\times10^{15} \text{ m}}$$

C. $1 \text{ ly} = 9.461\times10^{15} \text{ m}$ $$\frac{4.59\times10^{15} \text{ m}}{1 \text{ ly}} \boxed{= 0.485 \text{ ly}}$$

D. The time it will take will be 4.3 ly plus 354 days to reach light speed. The distance traveled to get to light speed is negligible, compared to the distance light can travel.

4.3 years + 0.97 years = $\boxed{5.27 \text{ years}}$

9) When jumping, a flea accelerates at 1000 m/s^2 (WOW!), but only for the very short distance of 0.50 mm. How high does the flea jump? (Ignore air resistance, because you haven't learned about it yet).

$S = S_0 + V_0 t + \frac{1}{2} a t^2$ $\quad 1000 m/s^2 \cdot 0.0005 m = 0.5 s = t$

$= 0 + 0 + \frac{1}{2}(1000 m/s^2)(0.5 s)^2 = 125 m$

or $\quad t = \frac{0.0005 m}{1000 m/s^2} = 5 \times 10^{-7}$

$= 0 + 0 + \frac{1}{2}(1000)(5 \times 10^{-7}) = 1.25 \times 10^{-10} m$

10) For SCIENCE, you get permission to drop a watermelon off of the Empire State Building, which is 320 m high. Ironman happens to come by right at that instant, traveling straight down with a speed of 35 m/s. How fast is the watermelon going when it passes Ironman?

Since the watermelon has no time fall, it gains no speed. Ironman passes the watermelon going 35m/s, so the watermelon is traveling at 35m/s relative to Ironman.