Big Exam! #2

Most students are better at identifying a lens and moving from there. However, many still do not do this correctly. I request that you review section 1.8 on how to set up a problem. I've changed the wording for dynamics lens to be "because forces cause acceleration." Or at even better, something that describes the situation like, "because the force I put a force on the car that makes it accelerate." So, if you have a hardcopy of chapter 1, please make this change in the text.

Still many students are running to equations without setting up the problem. Please see that setting up the problem with no equations will start you off with a "C". Using equations without setting it up will earn an "F".

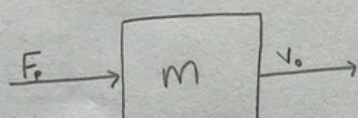
Please see below both methods and understand how you can use each… because you may have to. One is with an energy lens, and the other requires two lenses: dynamics lens and then kinematics lens.

You are pushing a car on flat level ground. The mass is 1000 kg, and you are pushing with a force of 500 N. If the car starts with a speed of 5 m/s and you push it forward 20 m,

a) What is the final speed of the car?
b) *How about if you push the car in the direction opposite its velocity for 10 meters?*

In order to get a "D" for this, you can draw a picture and then recognize that the work I do turns into kinetic energy. To get a "B", you'll recognize that the car already has kinetic energy so that the final kinetic energy of the car is equal to its initial kinetic energy plus the work I do:
$E_{kf} = E_{ki} + W$, where $W = \Delta E = F * \Delta x$.
For part b), we get a "B" if we recognize that the only difference is that my work *decreases* the kinetic energy, so it is negative. We could also see that this is the case because the displacement is in the opposite direction of the force (I'm moving backwards as I push). This student did a great job:

$m = 1000 kg$
$\vec{F}_p = 500N$
$\vec{V}_0 = 5 m/s$
$\vec{\Delta x} = 20 m$



$E_{kf} = \frac{1}{2} m (v_f)^2$

a) Final velocity?
Energy Lens $E_{kf} = E_0 + W$ $v_f = \sqrt{\frac{2E_{kf}}{m}}$

$E_0 = \frac{1}{2} 1000kg (5m/s)^2$ $W = 500N \cdot 20m$
$E_0 = 12,500 J$ $W = 10000J$

$E_K = 12,500J + 10000J$
$E_K = 22,500J$

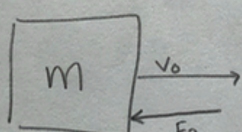
$22,500J = \frac{1}{2} 1000kg (v_f)^2$
$45,000J = 1000kg (v_f)^2$
$45 \, m^2/s^2 = (v_f)^2$
$\boxed{\vec{V}_f \approx 7 m/s}$

A

Now we can use same energy lense but $W = \Delta E$ is negative, because it ← will decrease E_K, because $\vec{\Delta x}$ + $\vec{F}$ are in opposite directions

b) $\Delta x = -10m$ Final velocity?

Energy Lens
$E_{kf} = E_0 - W$ (opposite direction) negative work reduces energy.
$E_0 = 12,500J$ $W = 500N (10m)$
$W = 5000J$

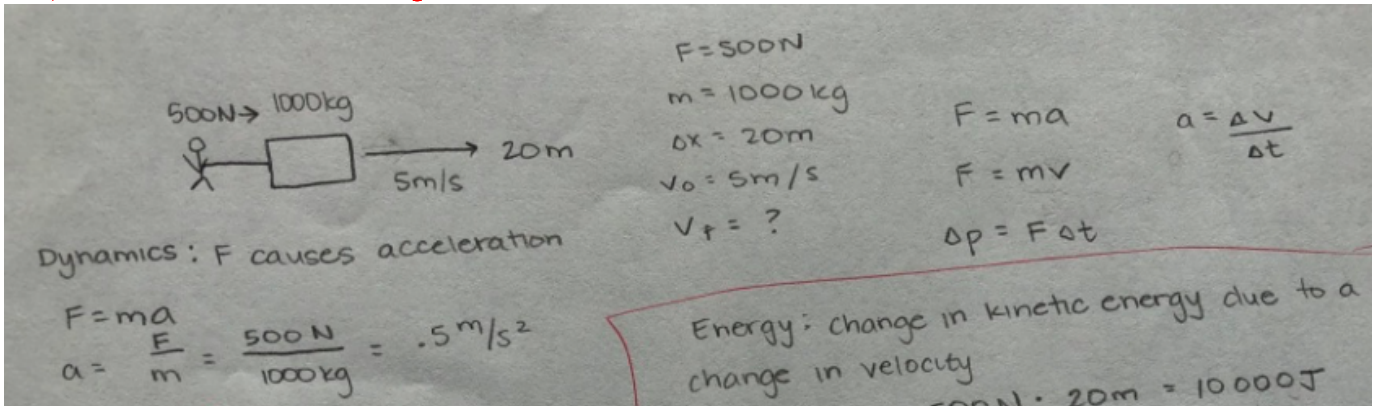


$7,500J = \frac{1}{2} 1000kg (v_f)^2$
$15,000 J = 1000kg (v_f)^2$
$15 \, m^2/s^2 = (v_f)^2$
$\boxed{\vec{V}_f \approx 4 m/s}$

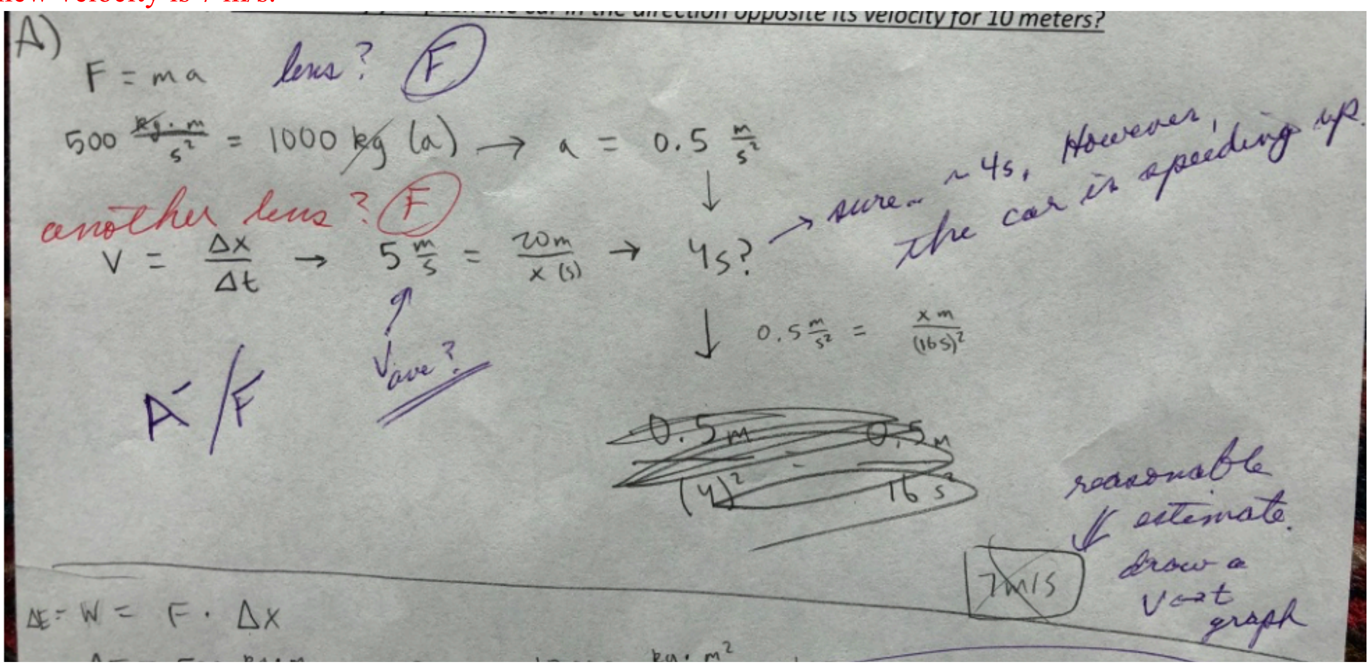
$E_f = 12,500J - 5000J$
$E_f = 7,500J$

I *entusiastically* applaud the above student for *estimating* the square roots wonderfully! This is *better* than using a calculator to get more precise answers (of 6.71 m/s and 3.87 m/s).

Several students set up the initial part of the dynamics approach and were able to find acceleration (for a "B"), but didn't know where to go from there with a kinematics lens:



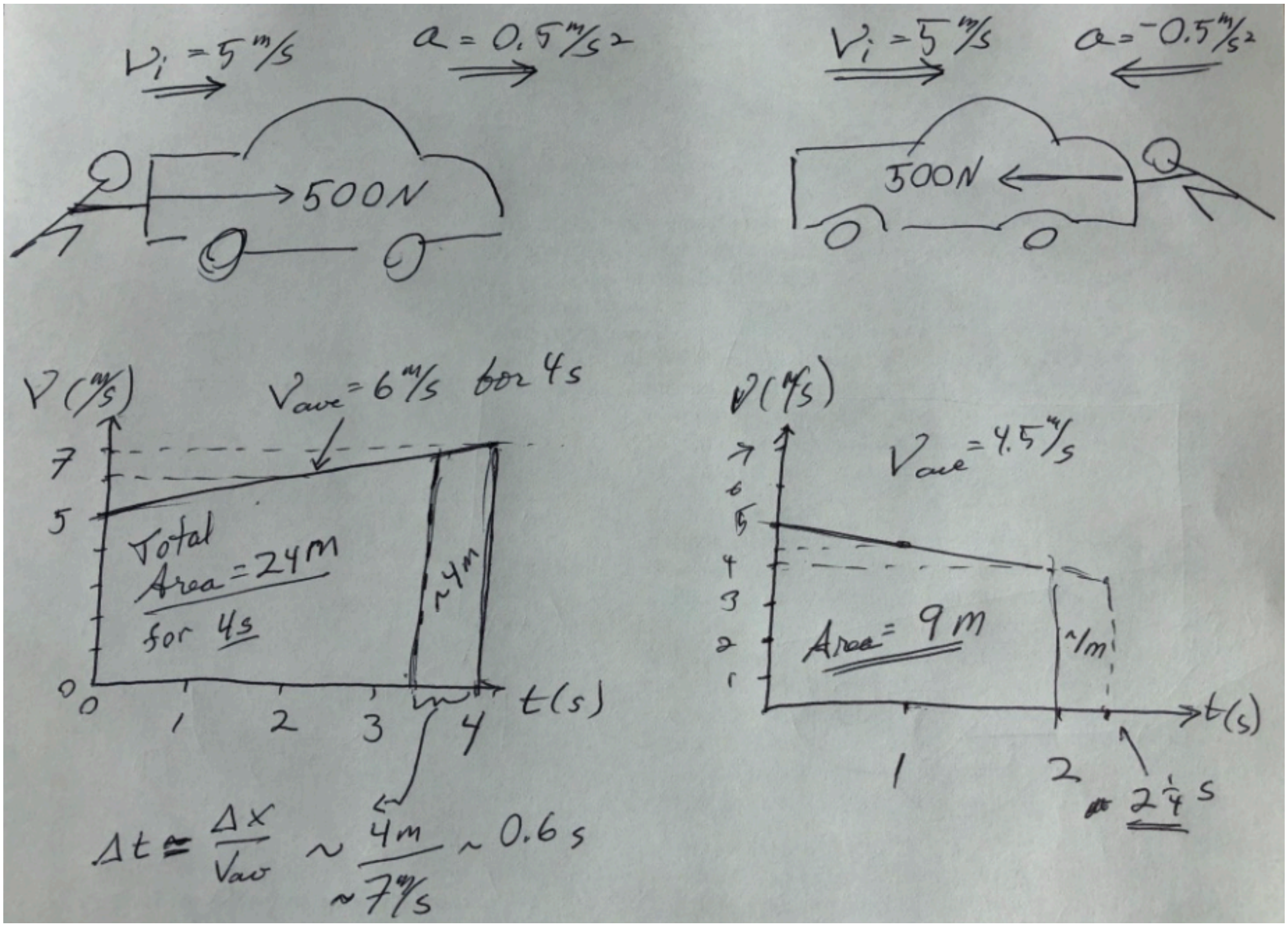
Where do we go from there? We consider motion as an explicit function of time! Where am I? What is my speed? My acceleration? Where will I be in the future. This student made a reasonable approximation: My speed is 5 m/s, so it will take me 4 seconds to displace myself 20 m, and at an acceleration of 0.5 m/s^2, my new velocity is 7 m/s.



However, with a final speed of 7 m/s, my *average* speed over the first 4 seconds is actually *6 m/s*, so I will have displaced myself *24 m* already, so I didn't actually push for 4 seconds, but closer to 3.5 seconds, yielding a final speed slightly less than 7 m/s.

Likewise, when I push in the opposite direction, we can use a dynamics lens to identify acceleration as – 0.5 m/s^2. Please show that it will take slightly *more* than 2 seconds for the car to move forward 10 m while I push it the opposite way (because I'm slowing it down), and thus, the final speed should be slightly *more* than 4 m/s.

The clearest way to look at these two situations is by making a v ⇔ t graph where the slope is the acceleration and the area under the curve is the displacement… at least one of you did this. See my efforts below.



Using these graphs, we could estimate the total times for a) ~ 3.4 s, and b) ~2.25 s, corresponding to final speeds of $v_f = v_i + at$ or a) ~ 6.7 m/s and b) ~ 3.9 m/s.