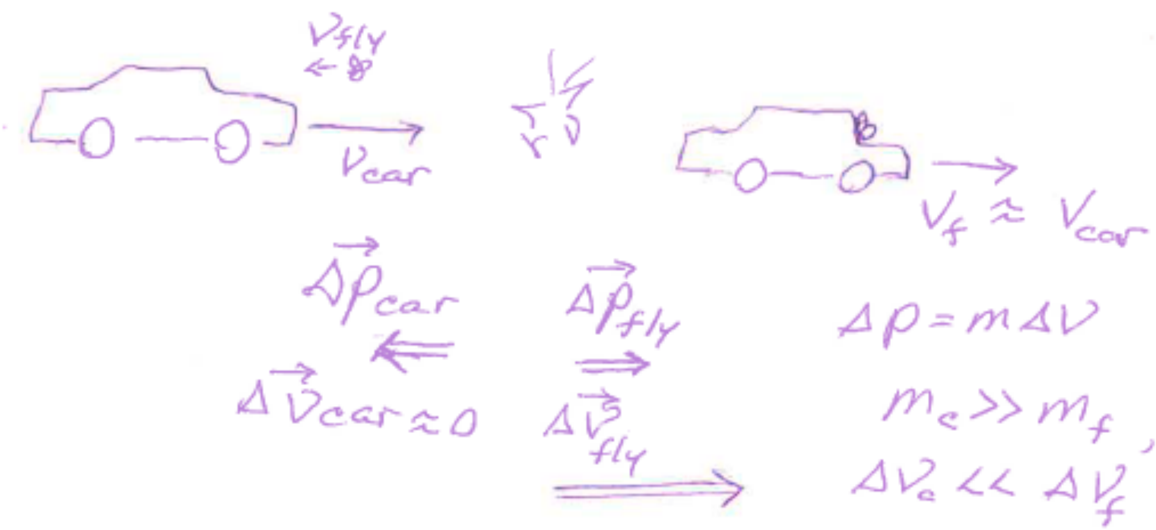
Problem Set #1, PHYS 141, Schwartz

My work is in *italics*

Please read textbook sections 1.0 – 1.4. While you are reading, please address the exercises. In particular, please do and hand in the following:

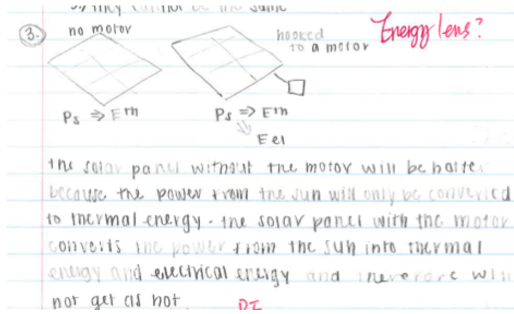
1. Exercise 1 in section 1.0, Describing your Problem-Solving Experience
   Lots of interesting answers here. Folks expressed that they appreciated the expedience of just using a formula. Additionally, most people expressed greater appreciation and satisfaction when they used concepts.

2. Exercise 1 in section 1.1, fly and window collision
   *This question and the "pushing off the boat" question (1.3 Ex.1) are essentially identical questions: pushing off something is like a collision in reverse, all the same laws hold. There is a force between the two objects, affecting each in opposite directions with same magnitude (because it's the same force). Because there are no outside forces, there is no change in momentum, so these two objects just exchange momentum. Each getting the same amount, but in opposite directions. These two observations are totally consistent because dp = F*dt. This doesn't mean that the acceleration or change in velocity of the two bodies is the same because they can have different masses. The extreme example is the fly on the windshield: they both have the same impulse (change in momentum), but because* $m_{fly} << m_{car}$ *the effect on each is very different. The car's velocity changes imperceptibly, and the fly's velocity changes a lot. For the pushing off the boat, imagine the difference if you push off the side of an ocean liner versus the side of an inflatable kayak.*



3. Exercise 3 in section 1.2, Solar Panels

The same amount of solar energy is absorbed. In one case, all this energy is converted to thermal energy. In the other case, it's converted to thermal energy and some electrical energy (to mechanical energy). If the energy can't go anywhere else, the solar panel connected to the motor receives less thermal energy and should therefore be cooler.



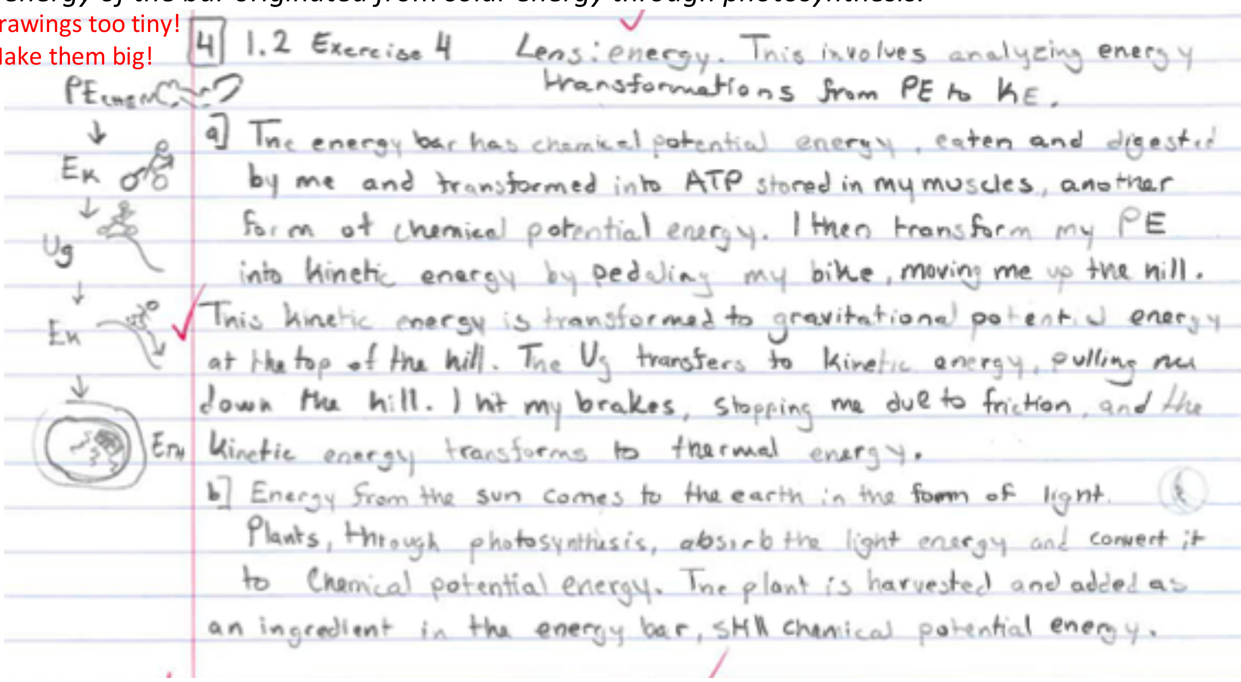
(3.) no motor | hooked to a motor | Energy lens?

Ps ⇒ Eth | Ps ⇒ Eth, Eel

the solar panel without the motor will be hotter because the power from the sun will only be converted to thermal energy. The solar panel with the motor converts the power from the sun into thermal energy and electrical energy and therefore will not get as hot. DT

4. Exercise 4 in section 1.2, Energy Bar Bicycling *The chemical potential energy (sugar in the bar) => kinetic (and thermal) energy in my body to the kinetic energy of the bicycle to the increase in gravitational potential energy climbing the hill, back to kinetic energy at the bottom of the hill to thermal energy in my breaks to the radiation of infrared light out into space. The chemical potential energy of the bar originated from solar energy through photosynthesis.*

Drawings too tiny!
Make them big!

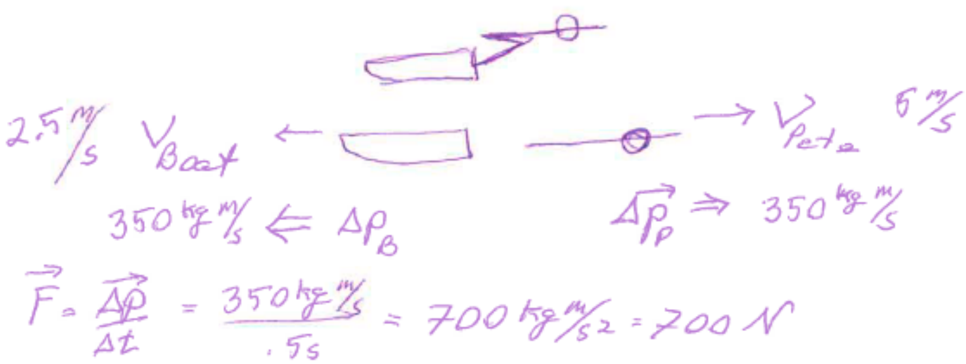


4 | 1.2 Exercise 4 Lens: energy. This involves analyzing energy transformations from PE to KE.

a] The energy bar has chemical potential energy, eaten and digested by me and transformed into ATP stored in my muscles, another form of chemical potential energy. I then transform my PE into kinetic energy by pedaling my bike, moving me up the hill. This kinetic energy is transformed to gravitational potential energy at the top of the hill. The Ug transfers to kinetic energy, pulling me down the hill. I hit my brakes, stopping me due to friction, and the kinetic energy transforms to thermal energy.

b] Energy from the sun comes to the earth in the form of light. Plants, through photosynthesis, absorb the light energy and convert it to chemical potential energy. The plant is harvested and added as an ingredient in the energy bar, still chemical potential energy.

5. Exercise 1 in section 1.3, Pushing off a boat,
please see the fly and windshield collision problem above.



1. [5] 1.3 Exercise 1 Lens : Dynamics : This involves an outside force and momentum. Changing the momentum of the system

$m = 70\,kg$ $v = 5\,m/s$

$m_B = 140\,kg$ push $T = 0.5\,s$

$a = \frac{\Delta v}{\Delta t}$

a] $a = \frac{\Delta v}{\Delta t} = \frac{5\,m/s}{0.5\,s} = 10\,m/s^2$ $F = ma = 70\,kg \cdot 10\,m/s^2 = 700\,N$

$F = ma = 140\,kg \cdot 10\,m/s^2 = 1400\,N$

$700\,N = \frac{\Delta P}{\Delta t}$

$\boxed{\Delta P = 350\,N \cdot s}$

b] Legs pushing give a force of $\boxed{700\,N}$

$F = ma = 70\,kg \cdot 10\,m/s^2 = 700\,N$

6. Exercise 2 in section 1.4, Rocket taking off

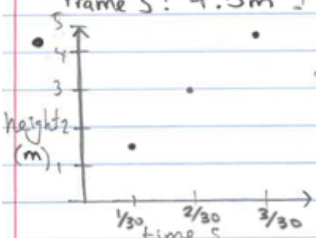
We use a kinematics (not kinetics. Kinetics means energy) lens because the video frames give us perfect measurement of position as an explicit function of time. Knowing that the frames are taken every 1/30 s. If the white launch tube is 60 cm high (and the boy is about 1.5 m tall), then the distance between the rocket positions in the first and second frame is about 2.25 m. We can use the definition of velocity to find a speed of about 67 m/s or about 155 mph!

Great!

[6] 1.4 Exercise 2 Lens : kinematics : we are determining values based on data of time and position.

Frame 1 : 1.5 m
Frame 2 : 3 m
Frame 3 : 4.5 m

Data based to scale that the kid in the frames is approx 1 m tall.



Speed $= \frac{1.5\,m}{1/30\,s} = \boxed{45\,m/s}$

$\frac{45\,m}{s} \times \frac{60\,s}{1\,min} \times \frac{60\,min}{1\,hr} \times \frac{km}{1000\,m} \times \frac{1\,mi}{1.61\,km}$

$= \boxed{100\ mi/hr}$

This is fast! I am surprised but don't think it unreasonable.