Problem Set #3 due beginning of class, Tuesday April 24. Please state the lens you are using and why. Remember that you are graded on your ***communication*** of physics understanding.

1. *not a true story. You have a mass of 50 kg.* On your trip to Dubai, you visit the tallest building in the world** and select the "extreme" elevator. You bring a bathroom scale and stand on it.
   a) You test the scale in the lobby by standing on it. What does it read? Why do you know it reads that?
   b) You ***hear*** that the acceleration on the elevator is 15 m/s^2. If this is the case, what should the scale read as the elevator begins its ascent?
   c) Near the end of the ascent (just before you come to your destination) you find yourself standing on the ceiling of the elevator, upside down, on your scale (scale against the ceiling), which now reads 300 N. Never mind how I got into this position, what must be my present acceleration?

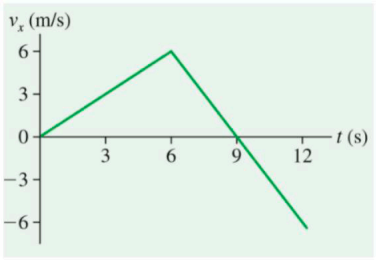
** https://en.wikipedia.org/wiki/Burj_Khalifa

2. *From an old midterm. Even if you've never heard of fusion, you have the basic skills to draw a picture and analyze this problem.* Fusion is the process that powers the sun and hydrogen bombs: small nuclei are fused into larger nuclei. One fusion process involves a triton (two neutrons and a proton – recall that neutrons and protons have about the same mass) and a deuteron (one neutron and a proton) fusing to form a supercharged 5-nucleon nucleus, which gives off its energy by blasting apart into a single neutron and a helium nucleus (or alpha particle) at high speeds. I want to know which of the particles gets more of the energy. Let's simplify the problem to just the explosive breakup: Protons and neutrons have the same mass, so we can think of this process as **a 5-ball cluster (in space, at rest) breaking up into one ball and a 4-ball cluster. Do the two pieces equally share the kinetic energy or does one get all or more kinetic energy?** You will be graded not on your answer, but on your reasons, drawings, and lens descriptions.

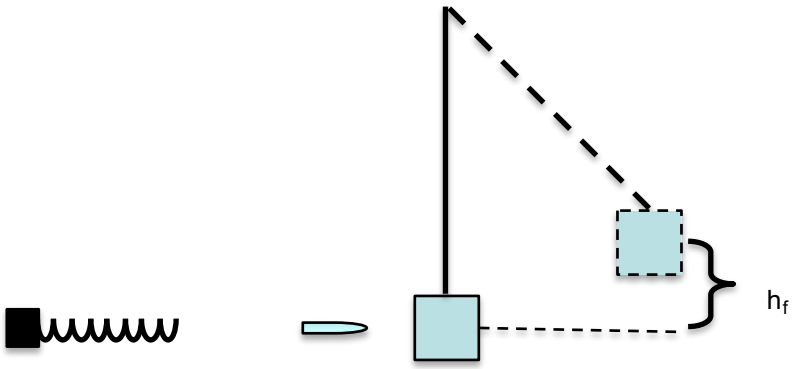
3. Exercise 6 in 2.4, Vectors pushing cars

4. Exercise 5 in 2.7, potential energy graph.

5. Please see the velocity time graph at right for an object that starts at x = -10 m. Please:
   a) Write a narrative – what is happening in the graph.
   b) Make an acceleration vs time graph.
   c) Make a position vs time graph.



6. A loaded gun is cocked by compressing a spring of k = 10^4 N/m. and then releasing it behind a 20 g bullet. The bullet strikes and sticks inside of a 0.5 kg ballistics pendulum and swings upward to a final height of 50 cm. Presume the spring is massless and there is no friction in the system. Please find:
   a) The bullet's speed.
   b) how far the spring was compressed.
   c) Does the bullet have constant acceleration in the gun, or does the acceleration change over time? Please explain your answer… identify a lens.
   d) Please find the maximum acceleration of the bullet in the gun.
   e) Did you identify the lenses at the very beginning, or one at a time for each question? Which do you think would be a better approach?



7. Using an energy lens, please show that if you drop a 5 kg box from 60 m, it hits the ground at ~35 m/s. But then, you *throw* the box *downward* from 60 meters height with an initial speed of 35 m/s.
   a) Find the speed that it has when it hits the ground.
   b) What if I throw it *upwards* at 35 m/s, what is the speed when it hits the ground?
   c) What if I throw it straight off the cliff at 35 m/s horizontally, what speed does it have when it hits the ground now?
   d) *Can* I throw a 5 kg box at 35 m/s? Please back up your answer.

8. According to the hydrodynamic flow equations you'll learn in PHYS-132, the speed of water coming from a 200 PSI fire house is about 45 m/s (~100 mph!). Wikipedia claims these hoses are 25 mm in diameter. Imagine if you were hit with water by one of these hoses, like if you were protesting the Dakota Access Pipeline, and the fire department was called to clear the area (please see some drama: https://www.youtube.com/watch?v=K3Iv9okL4QU). I'd like to know the force that this water puts on someone's body. Let's model the water as a moving column that hits you and disperses all directions perpendicular to its original direction of travel, as in the figure of the demonstrator at right.

   a) Clearly map out why this problem should be solved with conservation of momentum.
   b) What is the volume, mass and momentum of a 1-meter column of water *before* it hits your body?
   c) What is the momentum of water *after* it hits your body?
   d) How long did it take the water to change momentum?
   e) Find the force that this water puts on your body. Could it knock you over?

9. Imagine that you are traveling downward in an elevator at a rate of about 10 m/s, but you are slowing down at a rate of 2 m/s every second. The mass of the elevator is 1000 kg (with you in it). I want to find the tension in the cable holding the elevator.
   a) I bet you already made a drawing and are considering everything involved.
   b) Please consider all the lenses quickly. Choose one and provide the motivation.
   c) If you chose dynamics, why would you do this? I mean, what is your motivation?
   d) What is the complete *mathematical* relationship between forces and acceleration that define dynamics?
   e) If you haven't done it, identify these forces with a free body diagram!
   f) Why is it very (very very) important to identify the direction of acceleration in a FBD?
   g) Between the tension and the force of gravity, which force is larger or are they the same? Why can you be sure?
   h) With a forces diagram, show how you add the forces on the elevator to find the resultant force.
   i) Find the tension of the cable from which the elevator is suspended.