Problem Set #3 due beginning of class, Monday Jan. 29. 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

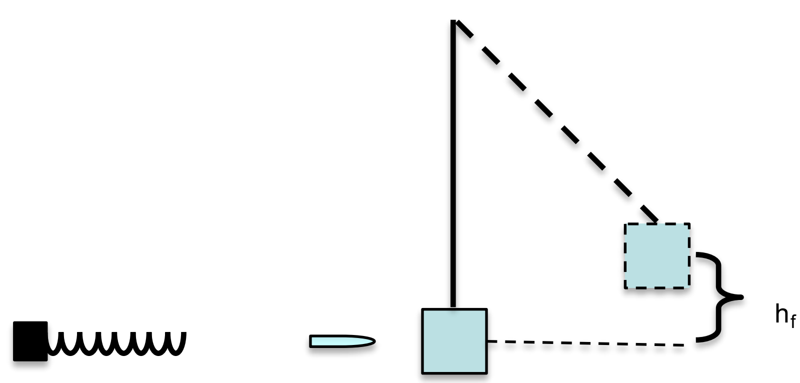
2. *From an old midterm. Even if you've never heard of fusion, you have the basic skills to draw a picture and analyze this problem.* Fusion is the process that powers the sun and hydrogen bombs: small nuclei are fused into larger nuclei. One fusion process involves a triton (two neutrons and a proton – 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

4. Exercise 5 in 2.7, potential energy graph.

5. An object starts at 10 m with a speed of 5 m/s and has an acceleration of – 4 m/s^2 + 2 m/s^3(t). Find the velocity and position after 3 seconds.

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. Exercise 1 in 3.0

10. Exercise 2, in 3.1, What are the final velocities in this elastic collision?

11. Dragsters have a mass of about 1000 kg and the best dragsters get to 44 m/s in about 0.8 s.

a) What's the acceleration?
b) Estimate the coefficient of friction necessary to make this happen if you were in a regular car on flat ground.
c) What's the average power output during this 0.8 s?
d) Dragsters have their exhaust pipes pointed *upwards*, which ejects a huge amount of exhaust straight up into the air at very high velocity. What effect does this thrust have on the ability of the car to accelerate? *Why? Please start with clarification of reasons, drawings, lenses.*
   According to my calculations, the engines kick out about 18 kg of exhaust every second at about 230 m/s.
e) What is the momentum of this amount of gas?
f) How much force should this put on the vehicle? In which direction?
g) With this extra "downforce", what coefficient of friction is necessary in order to accelerate the dragster?