PS#3… some questions from an old midterm: You're graded on ***COMMUNICATION*** of physics

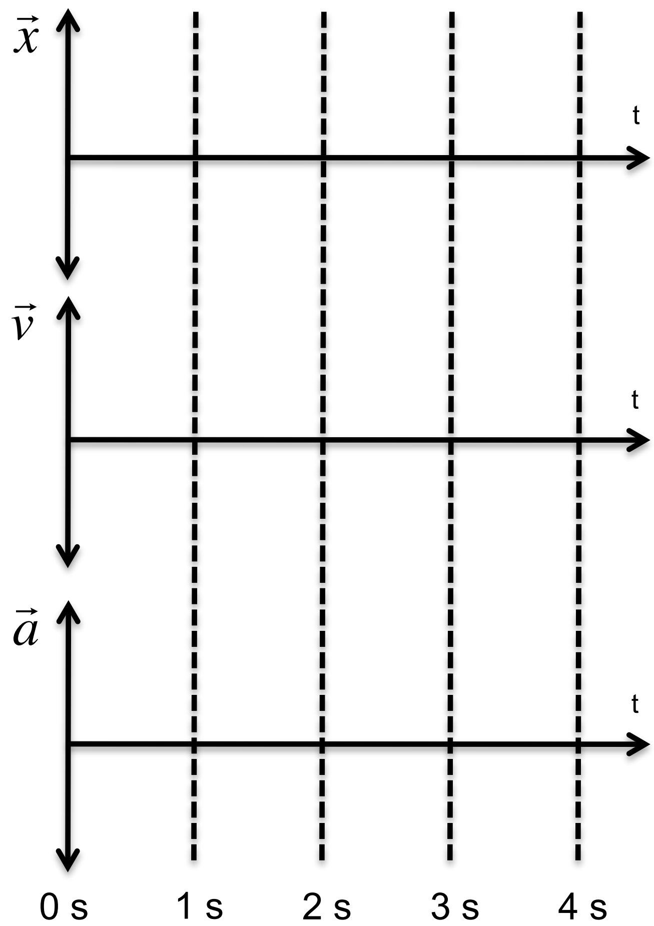
1) Fusion is the process that powers the sun and hydrogen bombs: small nuclei are fused into larger nuclei. One fusion process involves a triton (two neutrons and a proton) and a deuteron (one neutron and a proton) fusing to form a supercharged 5-nucleon nucleus, which gives off its energy by breaking up 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. I think I'd start by drawing a picture… could both pieces go off in the same direction? Why not? What's the problem here? What lens is best? Because there is no outside force, we know we must conserve momentum. Momentum must be zero because it starts at rest. Can you use this to find the ratios of the velocities? Kinetic energies?

2) Dragsters have a mass of about 1000 kg and the best 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 in a regular car on a flat level road. I expect to see a very good development with the dynamics lens to get ~ 5.5. Very few people recognized that the force of the engine *is* the force of friction. Consider a dragster on perfectly slippery ice.
   c) If the mass of a dragster is only about 1000 kg, what's the average power output during this 0.8 s? I get about 1600 HP – is that a lot?
   d) Dragsters have their exhaust pipes pointed *upwards*, which ejects a huge amount of exhaust at very high velocity *up into the air*. What effect does this thrust have on the coefficient of friction necessary to accelerate the car? *Why?* I expect to see a very good development with the dynamics lens to show how this innovation reduces the required coefficient of friction. How does the upward exhaust change the normal force? Please read more: https://en.wikipedia.org/wiki/Top_Fuel

Please start with clarification of reasons, drawings, lenses.

3) My friend at mass 50 kg is on a scale in an elevator headed upwards at a constant speed of 8 m/s for two seconds, and then in two more seconds, smoothly comes to a stop at a height of 20 m.

a) Please make the displacement, velocity, acceleration graphs at right. Show your work below, including lens explanation. Because I know where I finish rather than were I start, I have to work backwards finding change in displacement is the area under the v⇔t graph. I found that the starting displacement is -4 m.



b) Please calculate what the scale reads under my friend at t = 1 s, and at t = 3 s. Include discussion of lens and drawing I expect to see a very good development with the dynamics lens. Please see the elevator video again if you didn't do well on this. Most did horrendously here. There is an important protocol to follow… You don't have to follow MINE, but you do need to make use of a FBD and the vector sum of the forces = ma properly. I encourage you to see the elevator video again if you want to review this.

4) 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. This is straight up kinematics because we have motion as an explicit function of time. And it's calculus at its best. We have acceleration which is the time derivative of velocity, and the second time derivative of position. We could make the graphs and take the area under the curves, but we would probably be best of just integrating the accelerating and putting in the initial conditions of 5 m/s and 10 m. We know that

$v = v_o + \Delta v = v_o + \int a * dt = +\frac{5m}{s} - \frac{4m}{s^2}(t) + 1m/s^3 t^2$, and

$x = x_o + \Delta x = x_o + \int v * dt = 10m + \frac{5m}{s}(t) - \frac{2m}{s^2}(t^2) + \frac{1}{3}m/s^3 t^3$, and at $t=3s$, being meticulously careful of units, I evaluate:

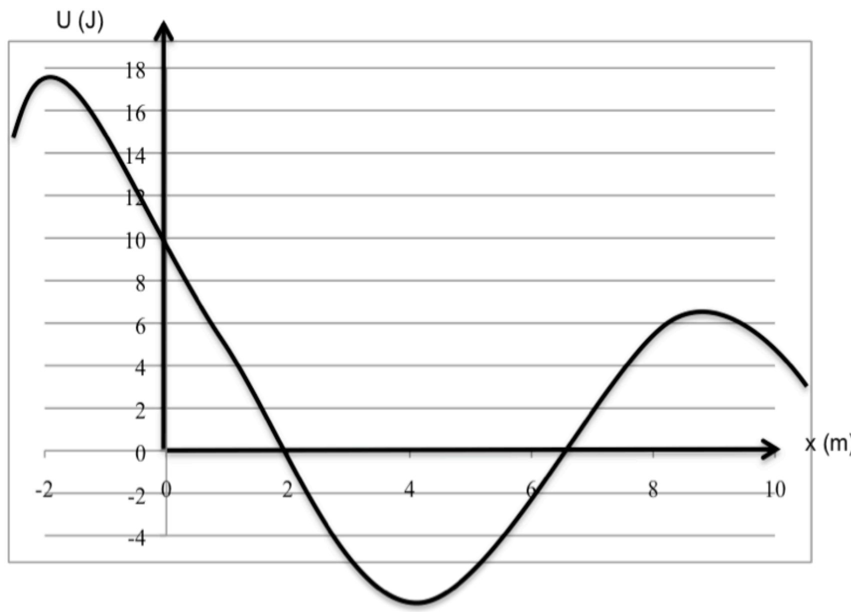
$x = 16\ m$, and $v = 2\ m/s$.

4) This problem is a shorter version of the second question in last fall quarter's PS#3, please see the answers to this problem. Again, available on the website: http://sharedcurriculum.wikispaces.com/Introductory+Mechanics+Spring+2016

You see below a potential energy diagram for a **2 kg mass**, as a function of displacement. (positive *x* is to the right). The mass **starts out at *x* = 0 moving at 2 m/s** to the left. *There may be more than one correct answer. In this case, list all correct answers.*

a) Label stable equilibria with "S"
b) Label unstable equilibria with "U"
c) Label any turning points with "T"
d) what is its speed at *x* = 6m?
e) What is the approximate acceleration of the mass at *x* = 6m? (What two concepts are necessary for this?)
Include direction in your answer, with a unit vector or an arrow.

Recognize that the cart is not *moving* up and down on the y axis. The movement is in the x direction only. The *y* component on the graph is the energy, which could be the result of some electric field, magnets, springs, rubber bands, etc.



5) 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. We might wisely consider an energy lens because *what kind of* energy turns into the kinetic energy at the bottom?
b) What if I throw it *upwards* at 35 m/s, what is the speed when it hits the ground? How does this change not not change the question?
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? How does this change not not change the question?
d) *Can* I throw a 5 kg box at 35 m/s? Please back up your answer. Consider using an energy lens… that kinetic energy comes from the force of my arm. How big does that force have to be? How does the energy lens help?

6) How fast did he throw the ball on Thursday? I remember that the 1947 g cooler moved back 10 cm when it was hit with the 41 g ball, and that the length of the string to where it pivoted was 60 cm. I think I got these numbers correct. This would be an energy lens alone except that in the inelastic collision of the ball with the cooler, a considerable amount of kinetic energy is turned to thermal energy. So, we need to use a momentum lens to navigate the collision. First we make a great drawing… Then we need to calculate the height the cooler rises. Using Pythagoreans Theorem, We find that the rise is about 8.4 mm. Using the energy lens, we know that this potential energy of the system swinging came from the kinetic energy of the system *after the collision.* Using this lens, I find that immediately after the collision, the cooler/ball system had a speed of about 0.41 m/s. We don't know about the kinetic energy of the incoming ball, but we know that the momentum of the cooler/ball system had to come from that incoming ball. So we conserve momentum, finding that the incoming ball had a speed of about 20 m/s… 44 mph. pretty quick.