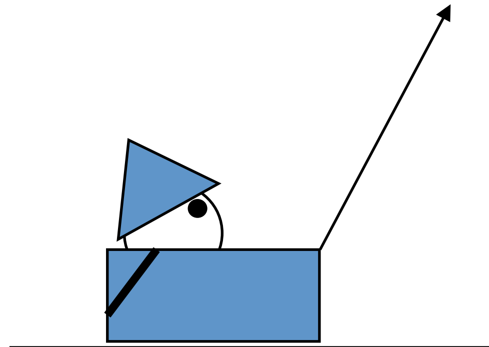
Problem Set #3 due beginning of class, Monday, Oct.13. 100 pts. total

*2 pts extra credit per extra person in the group – up to 8 points possible!*

*5 pts extra credit if you don't use a calculator: if so, write and sign a statement at the top of the problem set: "I [your name] did not use a calculator for any part of this problem set."*

#1. I pulled my daughter in a sled (total mass = 20 kg) on some frictionless ice as shown at right. I'm pulling with 80 N on the rope that makes a 60° angle with the horizon.



a) If we start from rest, what is her speed after I've pulled her 4 m? Start your answer by first explaining why using the work-energy theorem is the best way to solve this, and then find her speed.
b) *Using your answer from a) above* find out how long I pulled her. Start by explaining how this is a kinematics problem.
c) Repeat part a) above for the scenario that she is already moving at 6 m/s when I start to pull her.
d) What is the force that her little sled exerts on the ice?
e) If we start from rest, what is her speed after I've pulled her 4 *seconds*? Start your answer by first explaining why using the work-energy theorem won't work, and why dynamics is better, then find her speed.
f) Now find out how far I pulled her. Start by explaining how this is a kinematics problem.
g) Repeat part e) above for the scenario that she is already moving at 6 m/s when I start to pull her

#2. Ballistics Pendulum. Recently we are able to measure the speed of a bullet by taking a video of it with a high speed camera like Dustin does on https://www.youtube.com/watch?v=cp5gdUHFGIQ (for instance… Dustin likes guns, so there are lots of videos to choose from). However, years ago, in order to measure the speed of a bullet, one could shoot a hanging object, and the object with the bullet embedded would swing up. By measuring the swing upward, you could calculate the speed of the bullet. Please see this 5 s video: https://www.youtube.com/watch?v=cVjxn4KjOb4.

I have a spring powered gun that shoots a 2 gram bullet really fast. It has a massless, frictionless spring. I propel the bullet by compressing a spring of spring constant $10^4$ N/m by 10 cm. I fire the bullet into a 0.2 kg block of wood hanging from a string from the ceiling. After the mass has been hit, how high does the block swing?

a) Make a careful energy flow diagram of each step of this transition. Is the mechanical energy (kinetic+potential) conserved? If not, where might it have been lost? That is, there are many transitions: (1) I compress the spring, (2) I fire the gun, (3) The ball hits the pendulum, (4) the pendulum swings upward. For each step state the important transition(s) related to energy, momentum, forces, or motion.
b) Explain why you can't solve this problem with a single conservation equation, but rather that you may follow the process along each step.
c) Find the speed of the bullet and the height that the pendulum swings to after it is hit.

#3. The fuzzy dice (total mass: 200 g) hanging from my rear view mirror normally hang vertically. However, when I take off at a light, I see them tilted backwards at a constant angle of 20 degrees *below the horizontal*! Find the acceleration of my car and the tension in the string.

a) With meticulous attention to the protocol outlined in the dynamics video, please solve this problem. The answer is worth a point, but the process is worth many points, so please follow the protocol.
b) Could *your* car do this? Please make an argument as to why you know this isn't reasonable, or why this totally makes sense. – You can calculate the power output for the first two seconds if you like for a 1-metric-ton car, or by some other method.

#4. My friend and I drive off the road and can't get the car back on the road. However, luckily there is a big tree on the other side of the road 20 m from the car and my friend has his slack line in the car! We run the slack line between the tree and the car and tighten it as much as we can, but the car doesn't budge (This problem is dealt with in chapter 4 of your text).

a) My friend has a mass of about 50 kg and steps into the middle of the slack line making it sag only 10 cm. What is the effective spring constant of the slack line? Start with an indication of what kind of problem this is. If it's a dynamic problem, you are graded on the protocol.
b) What is the force that is on the slack line now with my friend on it? Start with an indication of what kind of problem this is. If it's a dynamic problem, you are graded on the protocol.
c) This doesn't make the car move, so my friend jumps up and down on the slack line as if it's a trampoline. With a thorough discussion of at least one of the concepts, please describe why this will or will not assist us. Answer may consist *only* of a discussion of the concepts of energy and dynamics.

#5. You're driving along due East at 20 m/s minding your own business in your 2000 kg truck when you are struck by a 1000 kg car. The two vehicles stick together with subsequent velocity of 10 m/s **due North**. Find the velocity of the other car before it hit you. Include speed and direction. Start with a discussion about what's happening with momentum, energy, and forces. Explain why this is a momentum problem and make sure you have a very good "before" drawing and an "after" drawing.

#6. Suppose you lower an object with decreasing speed (*follow the protocol for each question*):

a. Compare the force you exert on the object to the gravitational force on the object.
b. Compare the force you exert on the object to the force it exerts on you.

#7. Answer the two questions below with a yes and no answer *and a reason or example.*

a. Is it possible to have $v = 0$ and $a \neq 0$ ? If not, why not? If so, give an example.
b. Is it possible to have $a = 0$ and $v \neq 0$ ? If not, why not? If so, give an example.

#8. The river Kayasi flows westward through Viti Levu, the largest of the Fijian Islands at a rate of 4 m/s. I am in a boat on this river pointed due North traveling at 4 m/s. Isikeli is in an inner tube floating down the river, and Ratu Toka is watching us from land.

a) According to Ratu Toka, what are the velocities of myself and Isikeli?
b) According to me, what are the velocities of Isikeli and Ratu Toka?
c) According to Isikeli, what are the velocities of myself and Ratu Toka?