Problem Set #6 due beginning of class, Monday, Nov 3. 120 pts. total
2 pts extra credit per extra person in the group – up to 8 points possible!
3 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 If you hit a baseball at a 20 degree angle above the horizon, at an initial velocity of 20 m/s off the edge of a cliff 50 m high, how far away does it land from the bottom of the cliff? Please solve this three ways (one of the ways is problem #2, and tell me which you like best:

a) Using work-energy, please find the final speed of the ball. 37.4 m/s
b) Assert what you know about the horizontal component of the ball's velocity throughout its flight, and why you know this. Then, use this information to find the ball's vertical velocity and the angle it makes with the horizontal just before it hits the ground. Horizontal speed ~ 19 m/s is constant in time, so using Pythagorean, we have a final vertical velocity of 32 m/s and an angel of about 60 degrees.
c) Knowing the initial and final vertical components of velocity, find the amount of time the ball is in the air, and then the horizontal distance the ball went before landing. ~ .7 s going up, and 3.2 s going down. Horizontal distance is then 75 m

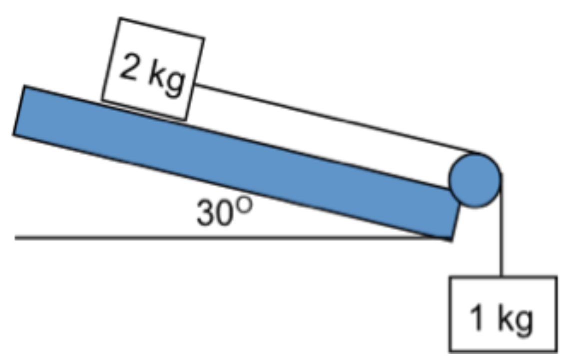
**Then try the kinematic method (d-f below):

d) Without finding energy first, please separate the problem into two parts, the horizontal and the vertical. You are looking for the horizontal displacement. However, you need to know how long it is in the air. Please solve the vertical part to find out how long it is in the air. It will go up for .7s, and arrive at a height of 52.5 m, and then go downward for about 3.2 s
e) Then you can use this time to find the distance that the ball has moved horizontally. Please show all your work and cancel units. Same as above
f) Find the final velocity (magnitude and direction), of the ball immediately before it hits the ground. Same as above

#2 Please download the Excel spreadsheet for this HW. The spreadsheet is about hitting a baseball. Notice how the horizontal and vertical displacements are calculated independently, but rely on the initial conditions that you put in in column K. Please figure out how the program works by looking at what it does and feel free to change some numbers (especially in column K). If you mess up the spreadsheet, you can fix it, or you can just download it again. What happens to the value of the angle as time progresses?

a) Explain how the program calculates the position at any given time, and the velocity at any given time. How does the calculation of the horizontal component of velocity differ from that of the velocity's vertical component?
b) If you are hitting on level ground, the story ends when the baseball gets back to 0 m in height. Please play with the velocity of the ball. If you double the initial speed (in column k), what happens to the distance the ball is hit? Can you explain physically why this happens?
c) Change the initial angle of the ball. Does it seem that a 45° angle maximizes the distance the ball is hit? Now hit the ball at an initial velocity of 20 m/s from the top of a 50 m cliff. You can change the initial vertical displacement in G2. Now see which angle maximizes distance. Why has it changed?
d) Now change the angle of the initial velocity, and solve problem #1 above. Which of the three ways to solving the projectile motion problem do you like best? Do you see different advantages to each?

#3 The system at right is started from rest. The coefficient of friction is 0.3. The strings and pulleys are massless and frictionless. The 1 kg mass hits the ground after falling 2 meters



a) How many joules in heat were liberated in the process? 10.4J
b) What is the change in potential energy as the system falls? -40 J
c) without using any kinematic equations, find the speed of the system when the 1 kg mass strikes the floor. What physics concept is used? Work energy theorem, 29.6 J is shared between the two masses at the same speed. v ~ 4.4 m/s

d) Using the information above, find the average speed, the time of the fall and the acceleration of the system. $V_{ave} \sim 2.2$ m/s, t ~ 0.9s, a ~ 4.9 m/s^2

e) Using the above information, find the tension in the string. T ~ 5.1 N

#4. Solve the above problem using dynamics as a system. Find the acceleration tension in the string and final speed.

#5. Solve the above problem using dynamics as two connected masses, solving the dynamics for each mass. Find the acceleration, tension in the string, and final speed.

Which of the three methods #3, #4, or #5 do you like the most?

#6. If team A and team B are engaged in a tug-o-war, then they want to pull very hard on the rope between them. However, they know that the tension in the rope pulls their team as hard as it pulls the other team, so they are confused. Is there no point in pulling? What are we missing here? Please outline the physics involved and explain what needs to happen in order for one team to win. This is a dynamics problem, can you follow a protocol that is compelling? You must consider how hard the feet are pushing on each side. Draw a FBD of each team showing force of feet, gravity and tension. What is the net force on the team if they win? How can you make this happen. Also, look at this as a system. With Tension not even considered because it's an internal force. Then you have force of feet upward in each direction and gravity downward. Or you could look at it in terms of frictional force on each team rather that the force of pushing feet and carry out the same above drawings.

#7 Two masses approach each other head-on with equal speeds (v_O = 10 m/s). The one from the left has three times the mass as the one from the right. If you like, the one from the right can be 1 kg, and the one from the left be 3 kg, or just allow them to be m_o and $3m_o$. *For full credit, draw good pictures of before and after as seen in both reference frames.*

a) Let's say they have a (totally) inelastic collision, sticking together. What's the final speed? 5 m/s

b) This speed is called the speed of the center of mass. Put yourself in this reference frame… pretend you're moving at this speed watching the collision. What do you see happen (Provide numbers and draw the picture? Big mass comes at 5 m/s, small mass at 15 m/s

c) For b) above, what is the momentum of the ball approaching from the left? From the right? What's the total momentum of the system? +/- 15 m_om/s. total p = 0

d) For c) above, now say that they have a perfectly elastic collision. What must be the speed of each ball after the collision in this CM reference frame in order to conserve momentum and energy?

e) What would the person in the laboratory frame (the earth's reference frame) see? What are the final speeds of each ball? Big mass is at rest, small mass v = 20 m/s

f) Find the total momentum of the system before and after the collision 20 m_o m/s

g) Find the total energy of the system before and after the collision 200 J

h) Was momentum and energy conserved in this elastic collision? Wonderfully, yes.