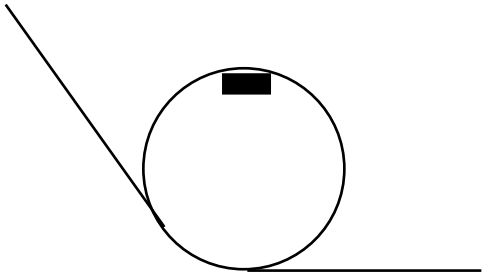
Problem Set #6. Hand in Monday, Nov. 2. I expect to collect it at the beginning of class this time because there is no new material in Monday's videos.

#1 You go on a R = 10 m, loop-de-loop ride at the carnival, but you have to choose how high to start the cart. Say you have a mass of 70 kg, like your instructor and you are sitting on a scale that reads in kg.



a) If you start from a vertical height of 40 m, what does the scale under you read as you are at the top of the loop? What does it read at the bottom of the loop as you enter the loop? Is this a good ride for pregnant women? How does it feel as you round the bottom of the loop?
b) What would happen if you decide to start the cart at the same height as the top of the loop? Why would this happen?
c) Please find the minimum vertical height, above the ground that you must start the ride to stay on the track.

#2 You see a 10 kg rock in space moving with constant speed of 10 m/s in a circle of radius 20 meters. I wonder what force is acting on this rock.

a) Why do you know the rock is accelerating if it is moving with constant speed?
b) Find the acceleration of the rock, including direction of the acceleration.
c) Calculate the force necessary to accelerate this rock.
d) What kind of force is this? – if you say, "it is centripetal force!" I will be sad. I will be pleased if you say, "I have no idea what force is acting on it, because I can't see anything that the rock is interacting with, so I have to look around at what object must be applying a force of_____(put answer from d) on the rock to make it accelerate at_____(put answer from c)."
e) Then you see a string attached to my arm as I spin the rock in a circle. What kind of force is it? Find the tension in the string.
f) Then the string breaks – what happens to the rock? Please Draw a Picture
g) ….instead of me and a string, you see a large sphere in the middle of the rock's circular path. What kind of force might be acting on the rock now? If this force is gravity, what must be the mass of the large sphere in the center? If the mass at the center has the largest possible radius of 20 m, what would be the density of the object? Is there any known substance with this density?
h) ….instead, you notice that the 10 kg rock is actually a small 10 kg toy car driving around in a 20 m circle on a flat parking lot at 10 m/s. Now what force is acting on the car? Please find the coefficient of friction necessary to keep the car moving in this circle.

#3 You are designing an extreme highway off ramp to allow people to make a 270 degree turn of radius 40 m without slowing down… so at 35 m/s (~77 m/h).

a) approximate without a calculator, the angle that you have to bank the ramp at so that a car on a frictionless road can make this turn. Also find the force that a 90 kg driver will feel while pulling this turn.
b) Use a calculator and trigonometry to find the above answers more exactly.

#4 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 two ways, and tell me which you like best:

a) Using work-energy, please find the final speed of the ball.
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.

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.

Then try the kinematic method, which is the way it's done conventionally (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. Which lens will you use?
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.
f) Find the final velocity (magnitude and direction), of the ball immediately before it hits the ground.

#5 Solve the infamous "catching the bus" problem. The bus is at your stop, and you're running at a constant speed of 7 m/s from behind in order to catch it. However, just when you're 20 m behind it (or behind the bus driver to be exact), the bus begins accelerating away from you at 1 m/s^2, and will continue accelerating at 1 m/s^2 unless you can meet eyes with the driver. Set up the problem properly with the right equations, substitution, solving the problem, and only at the end substituting the values in and solving the problem while canceling units properly.

a) Do you catch the bus? If so, at what time? If not, how close do you come?
b) Draw the displacement – time, and velocity – time graphs. Graph yourself and the bus together on each graph.
c) Repeat the above problem with the difference that the bus starts when you are 30 m behind it.