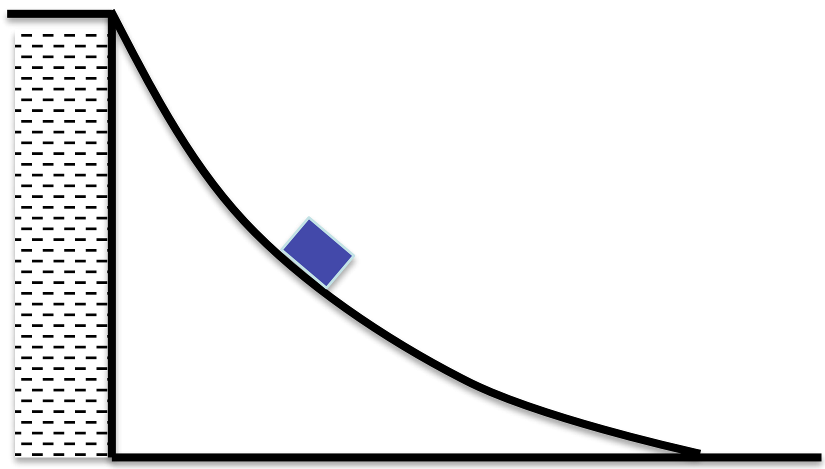
Problem Set #1 due beginning of class, Monday, Jan 11.

#1 A 5 kg mass is moving along in space at 16 m/s. It hits a 15 kg mass that is initially at rest. The two masses have a perfectly inelastic collision lasting 0.1 s, sticking together.

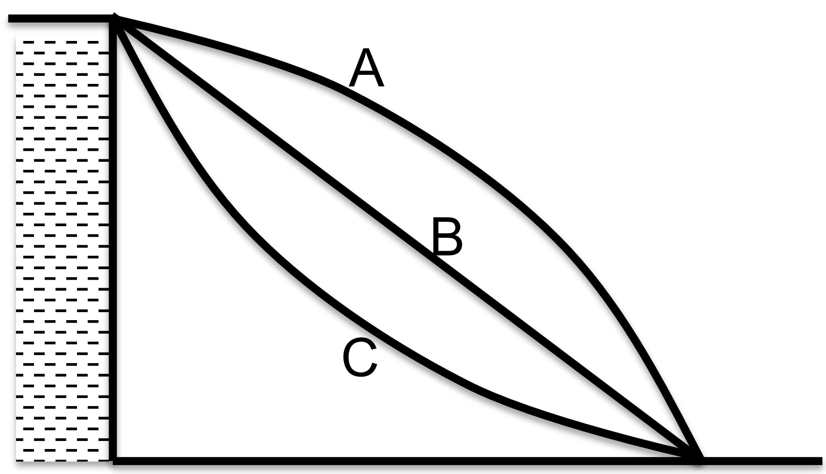
a) Can you calculate the initial momentum and kinetic energy of the 5 kg mass?
b) Can you calculate the final momentum and kinetic energy of the two carts stuck together?
c) Is kinetic energy conserved? If not where did the difference go (or come from)?
d) What is the change of momentum of each cart during the collision? This is called the *impulse* that each cart receives during the collision. What is the sum of the impulses of the two carts? … or what is the total change of momentum of the system?
e) Please calculate the average force acting on each cart during the collision.
f) Another way of looking at question c) is to express kinetic energy as $KE = \frac{p^2}{2m}$, rather than $KE = \frac{1}{2}mv^2$. First, please show that these two expressions are the same. Then describe how using the expression with momentum in it allows you to clearly show that you lose 3/4 of the kinetic energy.

#2 Imagine a 5 kg box sliding down a frictionless curved track at the edge of a 60 m high cliff as shown at right. We would like to know how fast it's going at the bottom. Neglect air friction.



a) Describe using each of the four lenses, what is happening in this process.
b) Please find out the speed at the bottom of the track.

Now imagine that there are two other tracks that the box could use as shown at right, bottom.



c) Which track should we use for the fastest final speed, or would all three tracks yield the same final speed? Please explain your answer.
d) How about if we wanted to know which was going the fastest *half way* down the total length of its path?
e) If three identical frictionless boxes were released at the top of each track, which would get to the bottom first, or would it be the same for all of them? Please explain your answer in terms of which lens you used.

#3 In the above problem, what if someone just dropped the 5 kg box off the edge of the cliff and it fell vertically downward?! Neglect Air Friction

a) What's the speed of the box at the bottom of the cliff (just *before* it hit)?
b) Did the momentum of the box change during the fall? Is momentum conserved in this process? Have we violated a conservation law? Are we in trouble?
c) If everything was at rest before we let the box go at the top of the cliff, we see that the speed of the box before it hits the ground is *not* zero. So, what must be the speed of the earth immediately before the box hits the ground? Include direction
d) What is the kinetic energy of the earth immediately before the box hits the ground? Would this be something important that we should consider when solving problems in the future? Why or why not?
e) Another way of looking at question d) is to express kinetic energy as $KE = \frac{p^2}{2m}$, rather than $KE = \frac{1}{2}mv^2$. Please describe how using the expression with momentum in it allows you to clearly show that we don't have to worry about the earth's kinetic energy.

#4 The roller coaster problem (balls on a track). People often claim that because the final speeds were the same, the average speed was the same, so they would all finish at the same time. I think our observations were otherwise. Please consider what was wrong with your reasoning. What was the underlying conceptual assumption you made that lead to this faulty prediction? Can you see where this was incorrect and correct it?

#5 Please finish the problem from Tuesday's class:

I) About how many km is in a mile?
II) Convert 1m/s into miles/hour.
III) On a linear track, I start at 10 meters and shuffle forward at 2 m/s. Beverly starts at 40 meters and runs toward me at 4 m/s.
   a) How long does it take for us to meet?
   b) Make a position-time graph showing each person's position as a function of time for the entire event.

**Beverly and I collide and stick together, completely at rest.

IV) Consider the momentum, Energy, Forces, and kinematics in this collision.
V) What do you know about our masses? How come?
VI) Are our initial kinetic energies equal? How do you know?