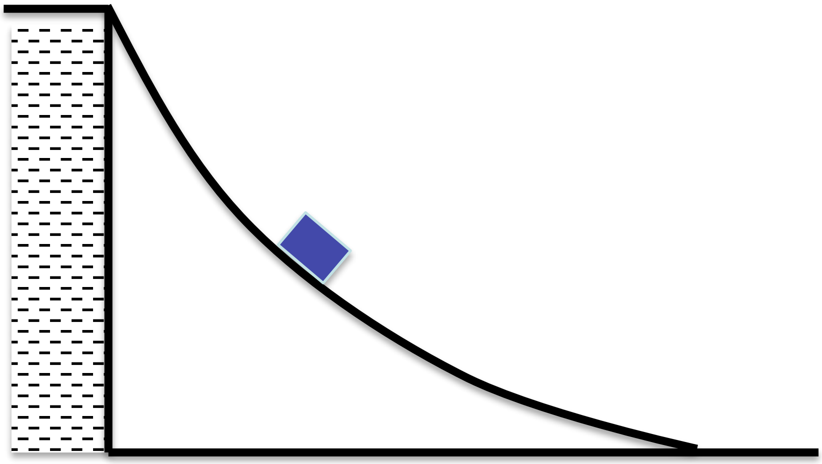
Problem Set #1 due beginning of class, Monday, Sept 28.

#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.

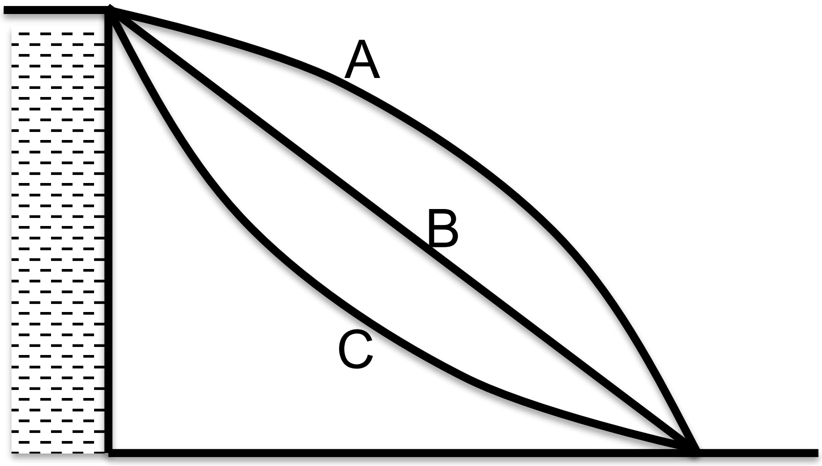
a) Can you calculate the initial momentum and kinetic energy of the 5 kg mass?
b) Can you calculate the final momentum and kinetic energy of the two carts stuck together?
c) Is kinetic energy conserved? If not where did the difference go (or come from)?
d) What is the change of momentum of each cart 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? As 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 Cars. Let's say I bought a 2000 kg (with me in it) car that has 150 hp!

a) What is this power in Watts? Yes, you'll have to look it up.

b) Let's say there are no frictional forces acting on the car (impossible), and the car could put out 150 hp at all speeds (also impossible, but getting better with a continuously variable transmission, no?) how fast is the car moving after 1 s? 2 s? 5 s? 10 s? Please make a rough sketch of the speed versus time graph. Before you did this problem, did you identify which lens you want to look through for this problem?

c) Make an energy flow diagram for the above energy conversion, but extend it in both directions so that it shows the conversion of energy all the way from the most fundamental energy source (radiant solar energy) to the most final energy form (dissipated IR radiation from the earth).