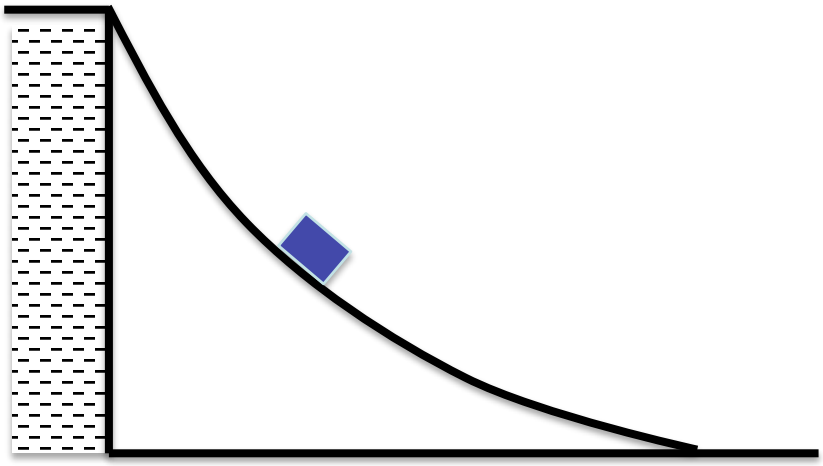
Problem Set #1 due beginning of class, Monday April 10

1. I inadvertently walk off a cliff. The process comes to a grim result 3 seconds later when I meet the ground. Please look at this process closely through all 4 lenses.
   NOTE: These questions may not be in the best order for answering them. My advice is to look through all of them quickly and start thinking about what's happening… did you make a drawing? That's usually the most important step in problem analysis.
   a) Momentum:
      i) How does my momentum change during the three seconds and there after?
      ii) Why should this be the case?
      iii) Can you make a rough graph of my momentum as a function of time from 0 seconds to 4 seconds?
      iv) Is momentum conserved during this process? Did I break the law of conservation of momentum?
      v) If it's true that momentum inside of a closed system must be conserved, please describe the full system we're talking about here.
   b) Energy:
      i) Please identify energy transitions or state why there are none.
      ii) What is the energy at the very beginning? What is the form of energy at the very end?
      iii) Was energy conserved? Please describe.
   c) Forces:
      i) Is there a force or forces acting on me? Please identify.
      ii) I've defined a force as an interaction between two bodies whereby momentum is transferred. Can you identify two bodies? What do we mean by momentum is transferred? What is happening?
   d) Kinematics:
      i) Can you describe my motion? What might my speed look like as a function of time. Can you make a speed vs time graph?
      ii) Can you describe my height as a function of time? Can you make a height vs time graph?

2. Two carts have an inelastic collision. A 1 kg cart moving at 4 m/s hits a 3 kg cart at rest. The 1 kg mass started at $t = 0$ at $x = 0$, moving in the positive x direction, and the 3 kg mass started at rest at $x = 4$ m.

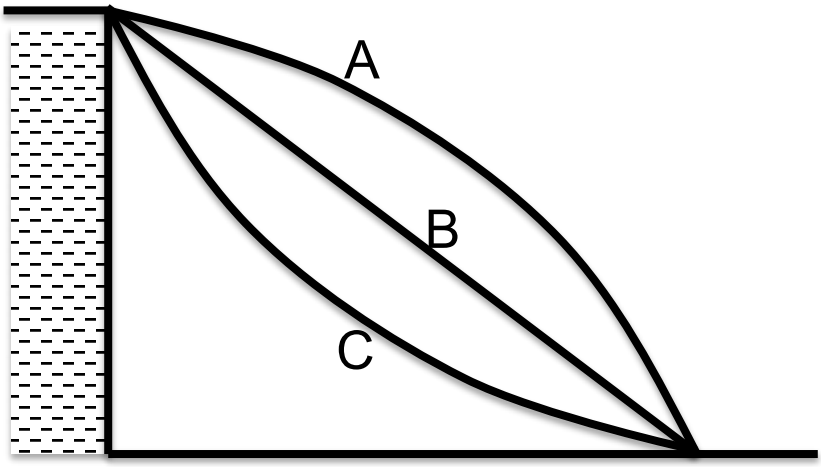
a) What is the total kinetic energy of the system before the collision?
b) What is the total momentum of the system before the collision?
c) What is the final speed of the two masses?
d) What is the final kinetic energy of the system and momentum of the system?
e) What is the initial and final momentum of each cart?
f) Was there any energy liberated as heat?
g) Please draw a velocity vs time graph showing the velocity of each cart on the same graph, for the first 5 seconds.
h) Please draw a displacement vs time graph showing the position of each cart on the same graph for the first 5 seconds.
i) If the collision lasted 0.05 seconds, what was the magnitude of the average force between the carts?
j) What is the acceleration of each cart during the collision? Define your lens and give support for it first.

3. 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) Which lens is the most helpful to find the final speed of the block at the end?
c) 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.



d) Which track should we use for the fastest final speed, or would all three tracks yield the same final speed? Which lens do you look at this problem through? Please explain your answer.
e) How about if we wanted to know which was going the fastest *half way* down the total length of its path?
f) 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.

4) I have a super smooth hill that I love to drop into on my skateboard. I have a mass of 70 kg. My daughter, Tekuru (30 kg) uses my cell phone to take a video of me as (starting from rest) I drop down this hill. From the video, we're able to measure my speed at the bottom at 10 m/s!

a) What is the change in elevation between the top and bottom of the hill?
b) How could we calculate speed from looking at a cell phone video?
c) Unfortunately, Tekuru took the video from the bottom of the hill on the flat part, and **BAM** I smacked right into her, but managed to grab her onto the skateboard with me. What was our speed after I hit her?
d) In a second attempt, I went down the same hill, but *started at the top* with a speed of 10 m/s! Tekuru took the video from the side this time. What was my final speed at the bottom this time?