Problem Set #2 due beginning of class, Monday Sept 25. Please state the lens you are using and why.

1. Please do Exercise 1 in chapter 1.5, rocket acceleration.

2. Taken from Exercise 3 in chapter 1.5. *Please be mindful to identify a lens for each step*:
   You push a 1000 kg car from rest on smooth level ground. It takes you 5 s to get the car to a speed of 1 m/s.
   a) What is the car's acceleration?
   b) What is the force you are exerting on the car?
   c) How does this force compare with the force of gravity on your body?
   d) Please imagine doing this in your mind. Does this sound reasonable?
   e) Estimate the power you put out accelerating the car.

   This is the first problem that requires the use of force units, the Newton, *N*. I haven't defined this unit, but we have defined and spoken about force already. Can you describe a Newton in terms of other more basic units to do this problem?

   **Please let me know if you find some mistake in the text (or a video), or if there is something that is confusing the way it is written. I appreciate any feedback that will improve the material for everyone.

3. Please read through exercise 8 in 1.6. What does this tell you about conservation of energy versus conservation of *kinetic* energy in a collision?

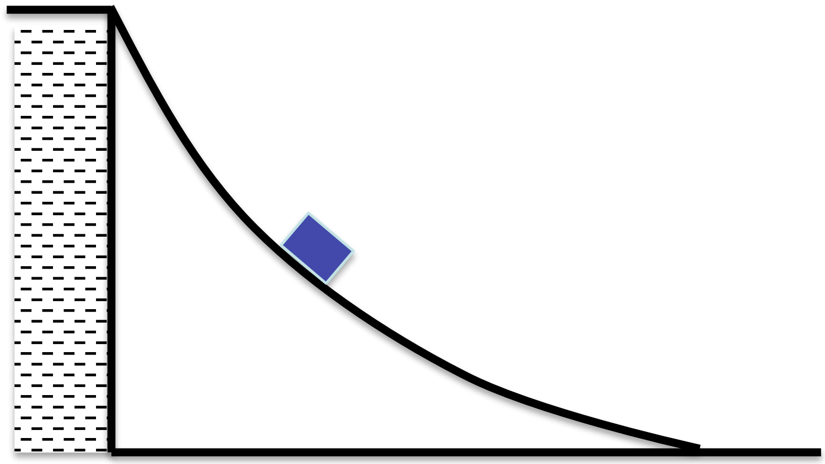
4. Exercise 1 in 1.9, scaling energy of a cart.

5. If I double the height from which I drop a rock, by what factor will this change the final velocity of the rock immediately before impact? That is if $\Delta H_B = \Delta H_A$, v_{fB} =_?__ v_{fA}. Please draw a picture of this, provide a lens and carefully consider.

6. 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 thereafter?
      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?

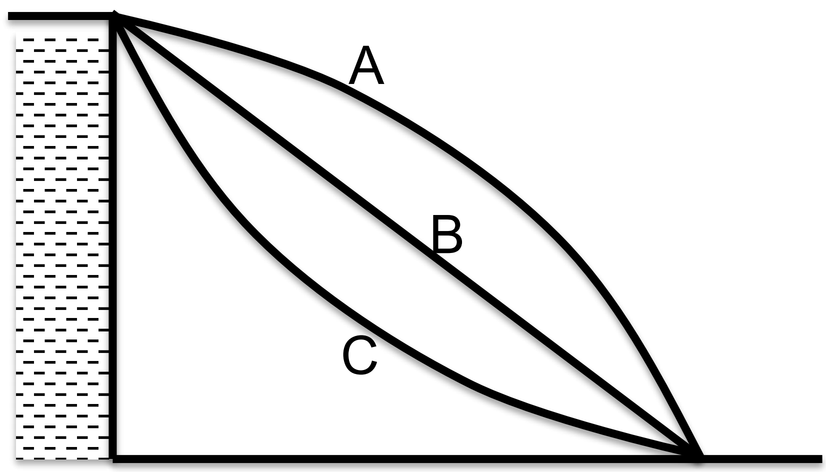
ii) Can you describe my height as a function of time? Can you make a height vs time graph?

7. 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.

8*** Very important!. Tuesday of Week 3, we will do our first of two projects. We will take kinematic movies of an activity. You will provide graphs of your movement as a function of time – position-t, velocity-t, acceleration-t, net force-t, kinetic energy-t, power-t. You will calculate the maximum power you put out. Please plan this activity in a group of 2-4 people. Please read more about the activity on the class webpage at http://sharedcurriculum.wikispaces.com/First+Project,+141+F17. Please propose an activity/experiment that your group could do.

9. Tracker Assignment,

Purpose: In this assignment, you will familiarize yourself with extracting kinematic information from a video. There are two ways that I know if that your group can extract this information:

1) Make a position vs. time graph estimating the distances frame by frame, the way I do it in the video assigned for Monday's class.
2) Use Tracker. This is super cool, but might be hard to make it work on your computer. I was not patient enough to make it work, but many students are good at this.

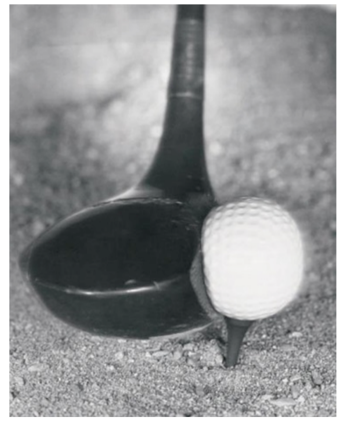
Parts:

You can find the grasshopper file at: https://www.youtube.com/watch?v=EoT_4B-gbRI&src_vid=O-JVepPdZbY&feature=iv&annotation_id=annotation_951640825

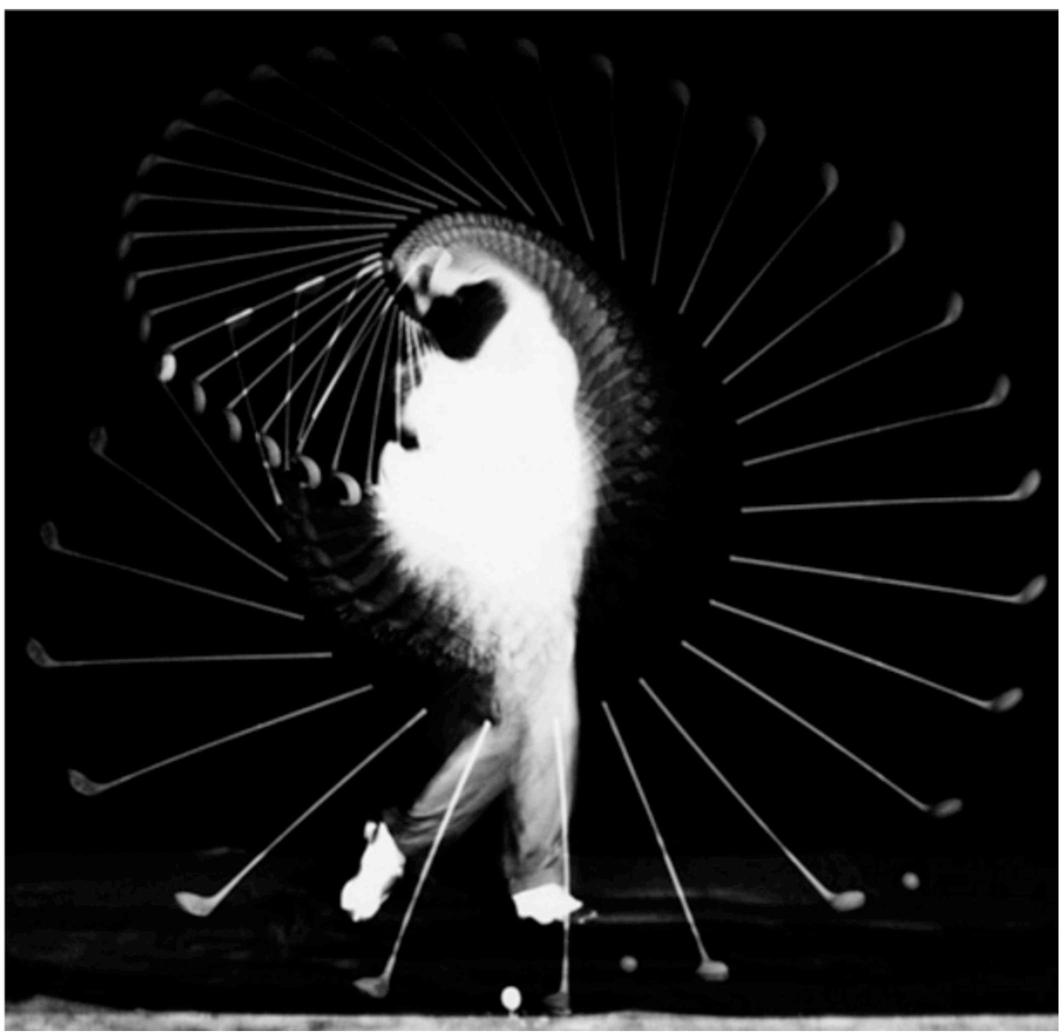
1. Watch the Smarter Every Day grasshopper video assigned for next Monday's class. Download the "Raw Grasshopper Jump Video" file located above. (The link at the end of the Smarter Every Day video is unreliable).
2. Please find helpful instructions also located for next Monday's class.
3. Repeat the Grasshopper experiment as described in the Smarter Every Day Video using the Tracker Software and come up with the acceleration of this other grasshopper video.
4. Do the best you can by using Tracker, Excel, or any other means to measure the acceleration of the Grasshopper. If you look in the lower left corner of the video, you'll see that the time is given to the *millionth* of a second and that the grasshopper begins the hop around 14 hours, 33 minutes, 26.6 seconds. You will have to make your own scale based on the length of the leg, but this is very doable. Do as good a job as you can.

10. Denny Shute (https://en.wikipedia.org/wiki/Denny_Shute) was a rather tall professional golfer in the 1930s. "Doc" Edgarton (https://en.wikipedia.org/wiki/Harold_Eugene_Edgerton) was a professor of electrical engineering at MIT who pioneered stroboscopic photography, where an ultra-short flash allowed a process to be illuminated on camera film for such a short time to freeze the process in time. His pictures of a bullet through an apple (http://www.bbc.com/future/story/20140722-the-man-who-froze-the-world) for instance made him famous, and when I was a student there in the early 80's his talks would fill the largest lecture halls with no standing room left. Edgerton photographed Denny Shute hitting a golf ball (http://artsalesindex.artinfo.com/auctions/Harold-Edgerton-5230133/Densmore-Shute-Bends-The-Shaft-1938) in the dark with multiple flashes at a frequency of 100 flashes per second.

a) In this photograph of Denny Shute's drive, how can you perceive speed? What lens do you look at this problem through?



b) Where is the golf club moving the fastest? How can you tell? Which lens do you use?
c) Where does the golf club speeding up and slowing down?
d) How does the speed of the golf ball compare to the speed of the golf club?
e) There was no flash at the moment that the club hits a golf ball. Where is the club when the ball is at the last two positions before leaving the screen?
f) Estimate the speed of the golf ball from this picture. Express it in m/s.
g) Roughly estimate the speed of a golf ball from your experiences. Close your eyes and imagine one being hit, or see a video: https://www.youtube.com/watch?v=8W89QnvY4Rg
h) When the club hits the ball, the ball speeds up. Should the speed of the club change as well? How do you know? What lens do you use?
i) From looking at the change in speeds of the ball and club on impact, can you make some statement about their relative masses? Can you estimate the ratio of the mass of the club to the mass of the ball?



j) Please estimate the amount of time that the club is in contact with the ball. You might do this by considering Edgerton's picture, or a careful look at this video at about 30 s: https://www.youtube.com/watch?v=6TA1s1oNpbk
k) Please calculate the average force between the ball and club during the collision.
l) Please calculate the average power provided by the club to the ball during the collision