Problem Set #3 due beginning of class, Monday Oct. 8. Please state the lens you are using and why.

Very important!. Tuesday of Week 2, we will do our first of two projects. We will take kinematic information from videos 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 project on the class webpage on our main class website. Please propose an activity/experiment that your group could do. This project (unlike regular homework) constitutes 5% of your final grade. It will be collected on Tuesday, Week 3.

1. My mass is 70 kg, and the mass of my bike is 10 kg. I'm riding my bike at a constant speed of 15 m/s. At 0s, my displacement is $x = -10\ m$. At t = 1s, I apply my breaks and smoothly slow to a stop over a period of two seconds.
   a) What lens do I use to make these graphs?
   b) Please graph my acceleration, velocity, and displacement as a function of time. Label the axes correctly.

   Then please also find:
   c) the force exerted by my breaks;
   d) and the work done by my breaks; and
   e) the average power.
   f) Was energy conserved in this process? How
   g) Was momentum conserved in this process? How?

2. 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 Tuesday'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

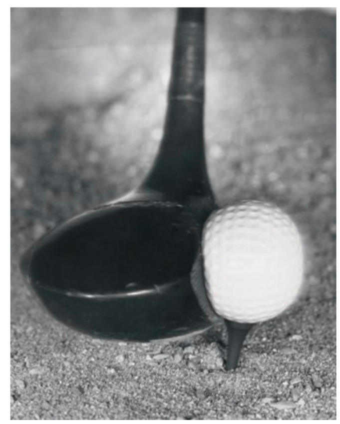
   1. Watch the Smarter Every Day grasshopper video assigned for Monday's class. Download the "Raw Grasshopper Jump Video" file located above. (The link at the end of the Smarter Every Day video is unreliable).
   2. Please find helpful instructions also located for Monday's class.
   3. Do the best you 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.

3. *not a true story. You have a mass of 50 kg.* On your trip to Dubai, you visit the tallest building in the world** and select the "extreme" elevator. You bring a bathroom scale and stand on it.

a) You test the scale in the lobby by standing on it. What does it read? Why do you know it reads that?
b) You ***hear*** that the acceleration on the elevator is 15 m/s^2. If this is the case, what should the scale read as the elevator begins its ascent?
c) Near the end of the ascent (just before you come to your destination) you find yourself standing on the ceiling of the elevator, upside down, on your scale (scale against the ceiling), which now reads 300 N. Never mind how I got into this position, what must be my present acceleration?

4. 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 is 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