Problem Set #2 due beginning of class, Monday, April 17

1. I fling a ball upwards at 20 m/s. *Answer: $h_{max} = 20$ m*

- When I look at something moving up and down without friction on a track or through the air, I always first think of energy. Here, the initial kinetic energy turns to potential energy and back to kinetic energy.
- When all the (initial kinetic) energy is converted to gravitational potential energy, the ball is at the highest elevation.
- I could also use kinematics because I know the acceleration is just a constant gravitational acceleration. Can you find the amount of time it takes the ball to get to the top, and can you find the *average* velocity?
- Inside of this we know that the force of gravity = dp/dt. This may or may not be helpful.

a) Find the velocity when the ball is 10 m above the take off point. It's important to know that at half the max height, the potential energy is half the maximum potential energy, and you've lost half the kinetic energy, but this doesn't mean that the velocity is half the max velocity. Using energy conservation please show that the speed at 10 m elevation is about 14 m/s.

b) Make a graph of the ball's velocity versus time. The slope of the velocity ⇔ time graph is the acceleration = -g. So, show that the v⇔t graph is a straight line from (x = 0s) (y = 20 m/s) to (x = 4s) (y = -20 m/s).

c) Using the graph above, make a graph of the ball's vertical position versus time. The slope goes from positive 20 m/s upwards to a flat line at 2 s at 20 m, and then the slope becomes more negative until the slope is – 20 m/s at a height of zero at 4s.

2. Cars. a 1000 kg car starts from rest and accelerates with uniform acceleration to 30 m/s in 5 seconds.

Did you draw a good picture? Did you label the things going on? Did you draw it at rest in the beginning and again at higher speed?

a) What was the average power put out by the car's engine? Please put answer in Watts and HP. This is an energy problem. What is the conversion that is happening? Cars are rated by their ability to do mechanical work. I get 90 kW or about 120 HP.

b) Is 30 m/s a very high velocity for a car? Imagine how long it would take to drive a football field.

c) What was the average force put out by the engine? There's a number of ways you could look at this. I would use the energy lens because work is F*dx, or Power is the Force*v. In this case it would be the average velocity. I get 6000 N

d) Then I lock up the wheels providing 10,000 N of force to slow us down, how long are the skid marks? You could use kinematics for this if you wanted, but I would again find this easiest to use energy because the energy used up would be the negative work you did on the car. I get skid marks 45 m long. It would take 3s by the way. Can you get this?

Please make three graphs: *a-t, v-t, x-t.* Ask me if you need help with this.

3. Wednesday, we will take kinematic movies of an activity. 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+S17

4. Tracker Assignment, *Please give this "the old college try". If you can't get it to work on your computer (I never got it to work with mine), then please have someone in your group show you how they got it to work on their computer. Otherwise, try doing it with Excel as I do with my motion on the track. Above all, don't let this get you down, it's not worth it.*

Purpose: In this assignment you will familiarize yourself with the Tracker software.

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

a) Watch Smarter Every Day. Download the "Raw Grasshopper Jump Video" file located above. (The link at the end of the Smarter Every Day video is unreliable).
b) Read the Instructions also located adjacent to this document on the Wikispaces website.
c) 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.

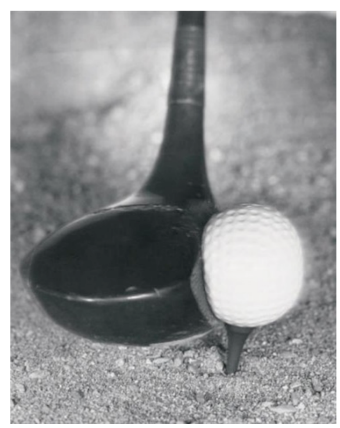
d) Do the best you can by using Tracker, Excel, or any other means to measure the acceleration of the Grasshopper. If you look in the lower left corner of the video, you'll see that the time is given to the *millionth* of a second and that the grasshopper begins the hop around 14 hours, 33 minutes, 26.6 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.

5. On your trip to Dubai, you visit the tallest building in the world** and select the "extreme" elevator. Near the end of the assent, you find yourself standing on the ceiling of the elevator, upside down, on your scale, which reads 100 N. This is surprising to you because your mass is 50 kg. What is your acceleration at this moment? Please big exam #2 solutions

** https://en.wikipedia.org/wiki/Burj_Khalifa

5. Solutions to this problem are on the assigned video.
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 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