Intro:
Our course starts with an in-depth study of oscillations: “motion that returns to the same place at the same momentum”. The tools are familiar from last semester, e.g. Newtonian mechanics, although the emphasis will be different. In addition to the physics of oscillations (with added features damping and driving forces), we’ll also study the mathematics of $F = ma$ - the idea that this equation is a “differential equation”.

I highly recommend that you read the “Reading” before lecture. Although you need not read the relevant sections in detail (that can wait until later), to “view” the new material before it is discussed will be a great help to you. I will try to keep the reading for lecture up to date, but I do find that the schedule slips a bit, especially when predicting further into the future. If/When that happens I will give the reading in class.

Due Wednesday, January 24, at the beginning of class.

Reading:
- Taylor Chapters 1 and Chapter 2, sections 1-6. Much of this is a review of uncertainties discussed in lab last fall. We will not be using the “Provisional Rules” discussed in Chapter 2. Instead we will follow what was done in Phys 190 and use quadrature.
- During the week:
  - Wednesday (Jan 17): HRW 15.1 - 15.2 and the first part of 10.1 in Kleppner and Kolenkow
  - Friday (Jan 19): HRW 15.2 and 10.1 in K&K
  - Monday (Jan 22): HRW 15.3 - 15.5
  - Wednesday (Jan 24): the Simmons e-Reserve reading and K&K “Small Oscillations of Bound Systems” on e-Reserves
  - Friday (Jan 26): Kleppner and Kolenkow 10.2 on e-Reserves and HRW 15 section 8

Physics Topics:
- Simple harmonic oscillation: springs, pendula, torsion, pendula...
- Energy in SHM
- $k_{eff}$

Math Topics:
- $F = ma$ as a differential equation

Problems:
1. (sig fig review) Go to [http://science.widener.edu/svb/tutorial/sigfigurescsn7.html](http://science.widener.edu/svb/tutorial/sigfigurescsn7.html) and complete 10 of the sig fig problems. For your “solution” record the number of correct answers and any questions you have on the exercises.
2. Taylor Problem 2.6. It’s on page 36.
3. In simple harmonic oscillation, when (if ever) are the displacement (“$x(t)$” with the origin at equilibrium) and velocity vectors in the same direction? When are the displacement and acceleration vectors in the same direction?
4. HRW Problem 15.8
(5) When a 81.2 kg person climbs into a 1180 kg old jalopy (an old car), the car’s springs compress vertically by 1.6 cm. What will the frequency of vibration be when the car hits a bump?

(6) HRW 15.21

(7) There is a very handy way to view oscillatory motion using a plot of \( v(t) \) vs. \( x(t) \).

(a) Working from our solution to SHM make a sketch of this motion where the \( x \) axis is \( x(t) \) and the ‘\( y \)’ axis is \( v(t) \). To get started assume that the oscillator starts at the origin and is moving to the right at \( t = 0 \). Follow it until it returns to the same point and direction. Don’t worry about getting the detailed geometry exactly right in this plot.

(b) Using the solution and \( v(t) \) algebraically determine the shape of your sketch.

(8) Old Data! On page 382 of HRW there is a nice plot of Galileo’s 1610 measurements on the moons of Jupiter, including Callisto.

(a) From the plot find the angular frequency and the (average) linear speed of the moon Callisto.

(b) Using Newton’s law of gravitational force and Galileo’s data, find the mass of Jupiter.

(9) Energy in oscillations:

(a) Given the relation \( F = -kx \), integrate (directly or by guessing the answer) to find the form of the potential. Recall that \( F = -\frac{dU}{dx} \)

(b) Sketch the potential energy well (by which I mean “the potential energy”), assuming \( k = 2 \) N/m.

(c) Use your graph to show the turning points of the motion of a mass with 4 J of total energy oscillating in this well.

(10) In an effort to measure a period of oscillation really well you start by making 10 measurements of a single period, obtaining the data: 1.29, 1.35, 1.25, 1.15, 1.19, 1.18, 1.12, 1.17 all in seconds.

(a) Enter these numbers in a spreadsheet and find the mean, standard deviation, and standard error. Write your result in standard form. You now have a result within 2% (right?)

(b) To obtain glory and search for new physics you wish to conduct a much better measurement. As a start, you time 20 periods and obtain a total time of 24.42 s. What is your result for the period with uncertainty?

(c) How many periods do you need to time to reduce your uncertainty down to 1 part in \( 10^3 \)?

In your solutions please submit a printout of your spreadsheet.

Lab:

Labs start this week! We will be working with a hanging mass on a spring.

A look ahead…

Next week we add some spice and complication to SHM by adding damping and driving forces. For a preview see HRW 15.8 and 15.9. The material is given a full treatment in KK 10.3.