Physics 213a-2011 Coverage for Exam 1

Reading:

Chapter 1: all;   Chapter 2: 2.1-2.3 only

Chapter 3: 3.1-3.4. (I expect you to know that we require $Q > ½$ for underdamped behavior, but I don't expect you to be familiar with the solutions for the critically-damped or overdamped cases.)

Class sessions: Start of semester through the first part of 9-19-11

Assignments: 1-3

Topics (topics in boldface are somewhat more important, but don't ignore the others):

Second-order differential equations (e.g. SHO):
- General solution has two adjustable constants
- **How to test a guess to determine if it's a solution**

Complex numbers:
- **Euler's equation**
- **Conversion between cartesian ($a + ib$) and polar ($Ae^{i\alpha}$) forms**
- Taking the Real part, including commutation relations with addition, taking derivatives, multiplying by real, multiplying by complex
- Taking the Imaginary part
- Representing in the complex plane
- **Correspondence between multiplication by $e^{i\alpha}$ and rotation in the complex plane**
- **Representing phase relationships between complex numbers by drawing them as vectors in the complex plane**

Solving motion problems:
- **How to go from a knowledge of an object's mass and the forces acting on it to writing down a DEQ which describes its motion**
- Being able to make reasonable guesses for solutions (in most cases, a guess of the form $x = Re(z)$, *where* $z = Ae^{-\beta t} e^{i(\omega t + \varphi)}$, where $A, \beta, \omega,$ and φ are real and are to be determined, would be reasonable)
- Determining the values of parameters (e.g. $\omega_0 = \sqrt{k/m}$) by substituting the guess into the DEQ
- Determining the values of adjustable constants (e.g. A and φ) from initial conditions
- Finding the phase and amplitude relationships between position, velocity, acceleration, and applied force

Simple (not damped or driven) harmonic oscillator:
- Hooke's law
- **Potential energy**
- **why any stable system can be modeled as a harmonic oscillator**
- be able to quickly write down and understand expressions (in complex exponential format) for and sketch position, velocity, and acceleration
- understanding the phase relationships between velocity, position, and acceleration; being able to represent these using vectors in the complex plane
- **extracting the actual motion from the complex exponential representation**
- **awareness that frequency does not depend on amplitude**
- **relations between and meaning of ω, T, and f**
- be able to quickly derive expressions for kinetic energy and potential energy, understand how the energy is traded back and forth between these forms during the cycle
- examples
  - elasticity & Young's modulus, including the meaning of yield stress
  - pendulums
    - be qualitatively aware of how this deviates from SHM at large amplitudes

effective spring constant for a pendulum

LC oscillator (isomorphism with mass on spring)

Complex notation for AC circuits

Expressions for impedance of *R*, *C*, and *L*

Extracting the actual *I* and *V* from the complex versions

Complex version of Ohm's law

Analysis of "voltage divider" circuits, e.g. low-pass filters, involving resistors, capacitors, & inductors

Damped harmonic oscillator:

DEQ of motion

definitions of and meaning of b, γ, and Q

underdamped for $Q > ½$, critically damped for $Q = ½$, overdamped for $Q < ½$

solution for underdamped case –

be able to quickly write down and understand expressions (in complex exponential format) for and sketch position, velocity, and acceleration

dependence of average energy and amplitude on time

relation between ω_v and ω_0, awareness that they are nearly equal except for very heavy damping

damped electrical series RLC oscillator

Miscellaneous

Taylor series

Slipperiness of the arctan and how to deal with it

General:

Be ready for problems that show harmonic motion/behavior but are not just a mass on a spring.

Get in the habit of using the force equation or the energy equation to find the effective spring constant and effective mass, and using these quickly to find ω_0. Similarly, get in the habit of picking out the effective value of b from the force equation, and using it, for example, to find the energy decay rate.

Be especially solid on all topics which appeared in starred boxes