PS232—Approximate Schedule of Lectures and Exercises

[Preparation: Weeks 1-6; Applications with Matlab: Weeks 7-11; Applications with Mathematica: Weeks 12-14.]

[*] BOMAB refers to the textbook, "Basics of Matlab and Beyond" by Andrew Knight.

[**] MFP refers to the textbook "Mathematica for Physics" by Robert Zimmerman & Frederick Olness.

Week	*Subjects*
1	*Math Review*: Trigonometry, vectors, matrixes, complex numbers, complex exponential, series summation and convergence, Taylor expansion. *Physics Review*: Newton's Laws, waves & wave equation, definitions of work and energy. *Exercises*: Math review sheet, physics review sheet.
2	*Introduction to Matlab*: Strengths of Matlab, the Matlab environment, the Matlab Help Browser, concepts of programming, matrixes in Matlab (.* vs. *, indexing, etc.), flow control. *Exercises*: Read BOMAB[*] Ch. 1-5, view online Matlab tutorials, introductory Matlab exercises.
3	*Introduction to Differential Equations*: Implicit functions and the concept of a differential equation, radioactive decay, free simple harmonic oscillator, free pendulum. *Exercises*: Solve DE's above with initial conditions, plot results in Matlab. Read BOMAB Ch. 6-10.
4	*Oscillations*: Phase space trajectory of the free pendulum, solution of the undamped driven simple harmonic oscillator, transfer function of the driven simple harmonic oscillator (Bode plot). *Exercises*: Check analytic solutions numerically, plot phase diagrams and Bode plots. Read BOMAB Ch. 11-15.
5	*Oscillations (cont'd)*: Damped simple harmonic oscillator, driven damped simple harmonic oscillator, *Q*-factor. *Exercises*: Write interactive Matlab code that parses user input and produces the appropriate plots for the differential equations discussed so far. Read BOMAB Ch. 16-21.
6	*Computing Basics*: Digital representation of numbers, round-off error, iteration, vectorization of Matlab code. *Exercises*: Write numbers in binary (incl. numbers in scientific notation), compute round-off error, Matlab vectorization exercise.
7	*Numerical Solution of ODE's*: Euler's Method, Midpoint Method, Runge-Kutta Method, Global Discretization Error, coupled DE's, second order DE's as coupled DE's. *Exercises*: Compare numerical solution (Matlab) and analytic solution to the damped SHO. Use ode45.
8	*Numerical Examples*: Orbits, orbital perturbations, predator-prey, Duffing equation, driven non-linear pendulum. *Exercises*: Practice solving the examples discussed in Matlab. Plot and interpret the relevant phase diagrams. **Midterm Exam**
9	*Fitting Data to Models*: χ^2 as the weighted distance to a fit. Uncertainty in the parameters. Parabolic approx. to the χ^2 surface (the error matrix), Matlab's basic fitting interface. *Exercises*: One parameter fit by trial and error, multi-param. fit by matrix inversion, fit using polyfit.
10	*Fitting Data to Models (cont'd)*: Linear fitting methods in Matlab, non-linear fitting methods in Matlab. *Exercises*: Plot χ^2 surface and parabolic approx. Use lsqcurvefit to do nonlinear fit to the damped sinusoid and illustrate false minima.
11	*Frequency Domain*: The Fourier transform, DFT, FFT, cross-correlation, autocorrelation, power spectrum. *Exercises*: Compute the various transforms on real data sets. Interpret the results (with guidance). Read Ch. 1 in MFP[**].
12	*Introduction to Mathematica*: Special strengths of Mathematica, the Mathematica environment, Mathematica's help documentation, symbolic computation, lists. *Exercises*: View the online tutorials, do simple analytic calculations. Read Ch. 3 in MFP.
13	*Oscillations*: Re-do some systems considered earlier in Mathematica (driven oscillator, driven Duffing eqn.) consider coupled oscillators, double pendulum. *Exercises*: Extend examples presented in class. Read Ch. 4 in MFP.
14	*Advanced Examples*: Hydrogen atom, Solitons. *Exercises*: Final Exam Practice.