# PHYSICS 105A 2016: Mathematical and Computational Physics.

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Office Hour: **Wed 2-3PM**, held in my office. I can also be reached by email.

**TAs:** **Grant Allen** grallen@physics.ucsd.edu
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**Text:** *Numerical and Analytical Methods for Scientists and Engineers using Mathematica,* by D. Dubin (Wiley, New York, 2003)

**References:** The Mathematica Book, by Stephen Wolfram
*Mathematica* Online Help

**Secondary Texts:** *Boundary Value Problems,* 5th Ed., by David Powers
*Differential Equations with Mathematica*, M.L. Abell and J. P Braselton
*Classical Dynamics of Particles and Systems,* 3rd Ed by J. B. Marion and S. T. Thornton
*Classical Electrodynamics,* 3rd Ed. by J. D. Jackson
*Numerical Recipes*, by W. H. Press, B. P. Flannery, S. A. Teukolsky and W. T. Vetterling

**Software:** *Mathematica version 11* will be available on laboratory workstations. Students may also want a copy of the software for their home computers, but this is not required. Note: UCSD will supply a free copy to enrolled students! Go to http://acms.ucsd.edu/services/software/available-software/mathematica.html and fill out the form.

**Lecture notes:** Lecture notes will be available for download from the class homepage as the quarter progresses.

**Class Location and times:**
Lectures will be held in **York 2622**
**Lecture Times:** TTh 8:00-9:20 AM
**Labs are in 4 sections: Th 12:30PM-3:20PM; 3:30-6:20 PM;**
**F 12:30PM-3:20PM; 3:30-6:20 PM.**
***Please come only to your assigned lab section***

The first 3 lab sections (Thur. and early Fri.) will be held in two locations (to accommodate overflow):
the computational physics lab, **MH4623** (4th floor, north-east end)
the Mayer Hall computer lab, **MH3421** (3rd floor, central hallway)
Currently the plan is for the late Friday lab section to be held only in MH4623, but this may change depending on demand.

The computer labs will be open 24 hours a day, 7 days a week, to 105A students, via a keycard lock using your student id. Bring your student id to the first lab so it can be scanned into the lock system.
**Note: the first lab will actually be a lecture, held in the Mayer Room, MH4322.**

**Other Available Computers**

Due to high enrollment, the lab may be full but *Mathematica* is also available in some other computer labs on campus, e.g. CH315, APM B432, APM B349.

**Assignments**

Every week several problems will be assigned. The assignment can be downloaded directly from the class website.

Problem solutions will be due at 6:20 PM on the Friday after they are assigned. The handwritten part of the assignment can be handed to the TA in the lab. There is also a drop box in the Physics Mail Room (MH3623) where you can submit your written work, or you can scan it and email it to a TA, or upload it on the TED website.

Part of your homework will be completed in the form of a *Mathematica* notebook. These notebooks are text files, and should be submitted electronically to the TED dropbox at the following address: http://ted.ucsd.edu

Assignments will be worth 35% of the class grade. Late assignments will be docked 10% per day for up to 6 days, after which they will not be graded.

**Problem Session/Laboratory**

The laboratory period is used to work on the homework assignment, and to ask the TAs (or me) for help.

Unless you are a math superhero, you will have to spend quite a bit of time on the homework assignments. The average time spent on the course is roughly 10-12 hours per week. Debugging computer code can take a long time. Start the assignments early in the week. Don't leave them until the day of your lab section, because you probably won't be able to complete them in time.

Tip1: Use the lab section to get help on problems that you could not solve yourself outside of the lab. You can also email me or the TA's with questions at any time, or come to the Wed. office hour.

Tip2: Keep a pencil and paper in front of you when working. You are smarter than your computer, so **do as much work as possible yourself using pencil and paper**. Only use *Mathematica* when you really need to, or if you think doing so will save time. (Note that this depends on your familiarity with the software.) **If you are stuck, take a break away from the computer to think.** (It is difficult to think and stare at the computer screen at the same time!)

Tip3: Computer coding demands precise input. Capitals matter. The type of bracket that you use matters. **Syntax matters.**

**Midterm and Final Exam:**

There will be an in-class midterm and a final exam. These tests will consist of two parts: a handwritten (analytic) part and a computational part that uses *Mathematica*. The midterm and final will be offered in three or four concurrent sections, depending on enrollment at that time. Details to follow later in the quarter.

Tentative Midterm date: Thursday, Nov. 3rd , 8:00-9:20 AM (week 6).
Final Exam date: Tuesday, Dec. 6th , 8:00-11 AM

The final exam will be worth 40% of your grade, and the midterm will be worth 25%.

**Class Web Page:**

The class web page, at http://ted.ucsd.edu should be a useful source of help and class materials. You will be able to find problem assignments there, as well as class notes, solutions, and grades as they become available.

**Academic Honesty:** Please read the policy on integrity in scholarship, in the General Catalog. You are expected to do your own work in homework and on tests. It is OK to get ideas from classmates for your homework solutions but copying is unethical and counterproductive. Anyone caught cheating will be subject to sanctions, up to and including expulsion.

# Course Outline

WEEKS 1, 2: Introduction to *Mathematica* (Chap. 9)

Defining numerical and analytic functions, vectors and matrices,
Linear algebra, eigenvalue problems, root finding, calculus,
Taylor expansion. Plotting functions in 2 and 3 D. Simple animations.

WEEKS 2, 3: Ordinary Differential Equations in the Physical Sciences (Sec. 1.1-1.5)

Initial Value Problems (IVP's)
Direction fields, phase space flows, Hamiltonian systems
Analytic and Numerical solutions via *Mathematica*: DSolve, NDSolve
Error propagation in numerical solutions: introduction to chaotic systems
Numerical solutions of IVP's with your own codes: Euler's Method, $2^{nd}$ -Order Predictor-Corrector method
Boundary value problems: the shooting method

WEEKS 3,4 Linear ODEs (Sec 1.6)

The principle of superposition
General solution of the homogeneous equation
Inhomogeneous Linear ODES: the forced oscillator
Exponential notation

WEEKS 4, 5: Fourier Series I (Sec. 2.1,2.2)

Fourier representation of periodic functions
Uniform and non-uniform convergence of series
Application: Response of an oscillator to periodic forcing
Fourier representation of functions defined on an interval
Even and odd periodic extensions
Application: Solution of a linear boundary value problem

WEEKS 6,7 Fourier Transforms and Green's Functions (Sec. 2.3,2.4)

Fourier representation of possibly non-periodic functions on the entire real line
Relation between a function and its Fourier transform: the uncertainty principle
Application: signal bandwidth and the bit rate
The Dirac $\delta$-function and its transform. Generalized Fourier integrals.
Application: Response of an oscillator to general forcing
Green's functions for initial-value problems: response to an impulse
Green's functions for boundary-value problems

WEEKS 7-10: Introduction to Linear Partial Differential Equations (Chap. 3)

The wave equation on a string
The heat equation in a slab
Laplace's equation in 2 and 3 dimensions
Separation of variables
Static Dirichlet, Neumann, mixed boundary conditions
Special functions: Bessel functions, Legendre functions, spherical harmonics
The wave and heat equations in 2 and 3 dimensions