

Mathematics 566
Numerical Analysis II
Spring 2010 (TuTh 9:15-10:30, MG 124)

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Office Hours: TuTh 10:35am-12:00pm, or by appointment

Text: B. Bradie, *A Friendly Introduction to Numerical Analysis*, 1st edition, Pearson Prentice Hall, 2006

Website: <http://math.boisestate.edu/~wright/courses/m566>

Course description: This is the second half of a yearlong introductory course on numerical analysis. The topics covered this semester include numerical linear algebra (solving systems of over/underdetermined linear equations, singular value decomposition, eigenvalues), fast fourier transform (FFT), numerical methods for solving ordinary differential equations (ODEs) (both initial-value and boundary-value problems), and numerical methods for solving partial differential equations (PDEs) (primarily finite difference methods, but, if time permits, we may also study spectral and finite element methods).

Prerequisites: MATH 565 or MATH 465 and the instructors permission.

Homework: Homework is posted on the class website every other Thursday. The problems involve a mix of theory and computing. Regarding the latter, please read the text below the **Programming** heading.

Your submitted homework should show all necessary work you used to solve the problems; mathematical statements should be complete (or nearly complete) sentences; and the reasoning and logic underlying all arguments should be clearly spelled out. Computer programs should be included along with numerical results presented in a readable format (e.g., in a table with headings or in a plot with labels). Please see the document “How to Present your Work” on the course web page for tips on meeting these requirements. **Failure to adhere to the above requirements may result in a loss of points.**

Homework assignments are due at the end of class every other Thursday. Late homework assignments are accepted up to three days beyond their due date. However, a 10% penalty is applied for each twenty four hour period they are late. This means that if an assignment is turned in after 10:30am on Thursday, but before 9:30am on Friday, then 10% is automatically deducted. Late homework assignments need to be brought to my office or, if you have the means, e-mailed to me. **Please indicate the date and time you put the homework in my box or I will assume it was turned in moments before I retrieved it from my box.**

Grading Policy: The final grade for the course is based on homework assignments, a midterm exam, and a final project. The breakdown for the course grade is as follows:

- Homework: 55%
- Midterm: 15%
- Final Project: 30%

Your lowest homework score is discarded. Note that unlike last semester, no portion of your midterm score can be discarded.

Programming: I highly recommend that you use MATLAB for all programming assignments involving numerical computations. An important part of numerical analysis today is the use of commercial or public domain software packages for solving particular problems. In order to gain exposure to this side of numerical analysis, students need to practice using such packages. MATLAB offers the perfect opportunity for such practice; it is one of the most dominant commercial computing environments. The MATLAB language is intended to be easy to learn and use, while still being extremely powerful. Three other reasons for using MATLAB for the programming assignments is that: 1) The webpage for the book contains a MATLAB implementation of several algorithms discussed; 2) My examples and homework assignments will use MATLAB code; 3) I will help you debug your programs.

There is a freeware “clone” of MATLAB called Octave (<http://www.octave.org>) that is also suitable for doing your programming assignments. However, note that Octave does not contain all the wonderful functionality of MATLAB.

If you have not used MATLAB previously, help resources are available on the course website and from the instructor. MATLAB is available in the Undergraduate mathematics computing lab (as well as various other locations on campus). You can also purchase a student version of MATLAB for a heavily discounted price from the book store.

Problems involving symbolic computations can be done using *Maple* or *Mathematica*. The former is available in the Undergraduate student mathematics computing lab.

Final Project: Instead of a final exam, you will prepare and present a final project to the class. The purpose of the final project is to investigate a problem in numerical analysis that interests you. For example, if you are a mathematician, you may be interested in comparing (in detail) the accuracy, stability and convergence of some different numerical methods we discuss, or perhaps developing your own technique. If you are a computer scientist, you may choose to implement (optimally of course) a software package for some complicated algorithm we discuss. If you are an engineer (or applied mathematician), you may be interested in applying a numerical method we discuss to some physical problem (for example, solving some ordinary or partial differential equations). The focus of your investigation should be primarily on numerical methods we discuss this semester, although exceptions can be made if a persuasive argument is made.

The final project will consist of a proposal for the investigation you wish to undertake (due March 18), a final **typewritten** report (5 to 30 pages), and a final presentation (15 to 20 minutes). More information about the project will be given as the semester proceeds. This does not mean that you should procrastinate until then; start thinking about a possible project now!

Important Dates:

- **Jan. 25** – Last date to add without a permission number on the basis of prerequisites and seat availability.
- **Feb. 1** – Last day to register; add classes; change from credit to audit or audit to credit; and last day to drop classes without a W and receive a refund (less \$25 processing fee) for Regular session classes.
- **Feb. 15** – Presidents' Day Holiday

- **Mar. 1** – Last day to drop or completely withdraw.
- **Mar. 29 – Apr. 4** – Spring break
- **May 9** – Classes end
- **Thursday, May 13 8:00-10:00am** – Final project presentations

Material to Cover: We will cover the following material (in roughly this order):

1. Numerical differentiation and integration (Ch. 6)
2. Ordinary differential equations – initial and boundary value problems (Ch. 7 & 8)
3. Partial differential equations – elliptic, parabolic, and hyperbolic (Ch. 9-11)
4. Discrete Fourier analysis (my notes)
5. Over/underdetermined linear systems (my notes)
6. Eigenvalues and Eigenvectors (Ch. 4)

References:

- Atkinson, An Introduction to Numerical Analysis (John Wiley and Sons)
- Dahlquist and Björck, Numerical Methods (Dover reprint 2003)
- Henrici, Essentials of Numerical Analysis (John Wiley and Sons)
- Fröberg, Introduction to Numerical Analysis (Addison-Wesley)
- Trefethen and Bau, Numerical linear algebra (SIAM)
- Golub and Van Loan, Matrix Computations (Johns Hopkins University Press)
- Demmel, Applied Numerical Linear Algebra (SIAM)
- Fornberg, A Practical Guide to Pseudospectral methods (Cambridge University Press)

The purpose of computing is insight, not numbers! –Richard Hamming

Computers are useless. They can only give you answers. –Pablo Picasso

It would appear that we have reached the limits of what it is possible to achieve with computer technology, although one should be careful with such statements, as they tend to sound pretty silly in 5 years. – John Von Neumann (1949)

The badly named real number system is one of the triumphs of the human mind. It underlies the calculus and higher analysis to such a degree that we may forget how impossible it is to deal with real numbers in the real world of finite computers. But, however much the real number system simplifies analysis, practical computing must do without it. – George Forsythe

Without precise calculations we could fly right through a star or bounce too close to a supernova and that'd end your trip real quick, wouldn't it? –Hans Solo