AME 60611–Mathematical Methods I
Fall 2011

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Course web site: http://www.nd.edu/∼powers/ame.60611

Listserver address: ame60611-01-fa11@acadlist.nd.edu. When e-mail is sent to this address, the entire class will be receive a copy of the mail.

Course time and location: MWF 12:50 PM-1:40 PM, 126 DeBartolo

Help Session: W 6:15-7:15 PM, probably 116 DeBartolo

Prerequisites: formally none, knowledge of undergraduate calculus through differential equations

Catalog description: "Multidimensional calculus, linear analysis, linear operators, vector algebra, ordinary differential equations"

Comments: The course will consist of a survey of elements of advanced mathematics. Topics will be as listed in the catalog with some additional material interspersed. A primary source will be the course notes. The texts, of which Kaplan is the most comprehensive, will serve as complements to the lecture notes, which are self-contained.

Notes available on the Web

M. Sen and J. M. Powers, 2011, *Lecture Notes on Mathematical Methods*,
http://www.nd.edu/∼powers/ame.60611/notes.pdf (required).

Texts available in Bookstore (and on reserve in Engineering Library)

W. Kaplan, 2003, *Advanced Calculus*, Addison-Wesley (required).
E. J. Hinch, 1991, *Perturbation Methods*, Cambridge (recommended).
P. G. Drazin, 1992, *Nonlinear Systems*, Cambridge (recommended).

Other Useful Texts

K. F. Riley, M. P. Hobson, and S. J. Bence, 2006, *Mathematical Methods for Physics and Engineering*, Third Edition, Cambridge.
C. M. Bender and S. A. Orszag, 1999, *Advanced Mathematical Methods for Scientists and Engineers*, Springer.

M. D. Greenberg, 1978, *Foundations of Applied Mathematics*, Prentice-Hall.
G. Strang, 1986, *Introduction to Applied Mathematics*, Wellesley-Cambridge.
G. Strang, 1988, *Linear Algebra and its Applications*, Harcourt Brace Jovanovich.
B. Friedman, 1990, *Principles and Techniques of Applied Mathematics*, Dover.
R. J. Lopez, 2001, *Advanced Engineering Mathematics*, Addison Wesley Longman.
L. Debnath and P. Mikusinski, 2005, *Introduction to Hilbert Spaces with Applications*, Academic Press.

Required Work and Grading

Exams will be closed book, closed notes and held in class. The final exam will be comprehensive. Calculators are not allowed on exams.

Homework will be assigned regularly. All homework will be graded and returned. Homework must be done on *one side only* of 8 1/2" by 11" *engineering* paper with no frayed edges. Multiple pages must be stapled. You should briefly restate the problem, give a sketch if helpful, give all necessary analysis, and place a box around your final answer. All plots must be computer generated, trimmed, and taped to engineering paper. Label all axes. Raw `Mathematica` or `Maple` output will not be graded. Neatness and effective communication are considered in grading as well as the final answer itself.

Two short (one page maximum) critical reviews of works from the literature will be required. The first review will consider a topic of current interest in applied mathematics from the journal *SIAM Journal on Applied Mathematics*. The second must consider an article on mathematics which has stood the test of time. It must be over fifty years old and written by a well-known mathematician. The articles you choose should *not* fall into the category of review, historical discussion, biography, or other version of "math lite;" rather, it should be a substantive, original contribution. Your reviews should 1) summarize the article's major findings and 2) offer an argument why this paper is deserving of its recognition. The reviews are required to be written in a LaTeX format and will be checked primarily for style, format, grammar, and content.

Grades will be assigned based on students' performance on examinations, homework, and papers. Pertinent information is as follows:

Exam I	20	Friday, 30 September 2011
Exam II	25	Monday, 21 November 2011
Final Exam	40	Friday, 16 December 2011, 8:00-10:00 AM
Homework	13	
Reviews	2	Friday, 23 September 2011; Friday, 18 November 2011
Total	**100**	

Honesty Policy

Academic honesty is expected. When confronted with an apparent violation, I will enforce the appropriate University regulations to the best of my ability. I will also try to make my expectations clear. By and large, though, these issues are out of my control and as such I do not seek out violations. Instead, I depend upon your basic integrity to prevent any problems.

In brief my expectations are as follows. I encourage you to freely discuss the homework amongst one another as you formulate your solutions *individually*. *Your* written work should represent *your* understanding of the problem. In practice this means copying (in whole or in part) another student's homework, exam, computer program, or paper is *not* permitted. If you choose to discuss your work with a colleague, it should be a discussion in which one teaches another or both work to a mutual understanding. As a counter-example, it is not acceptable to give a friend your homework five minutes before class so that friend can copy your work. I also consider it unacceptable to copy work from a student who was in the class in a previous year. In your written reports, be careful to correctly use quotation marks for words that did not originate with you. Paraphrasing should be held to a minimum, but if used, the paraphrased section should be specifically identified and unambiguously cited. It is not sufficient to simply list a reference but not indicate where a specific quotation or paraphrase was employed. In addition all sources used should be fully cited. As is done in the scientific literature, you should *briefly* acknowledge in writing any significant discussions or interactions you had regarding the work you submit. As a general principle, I do not accept the justification that you were not sure of my intentions. If you feel you may be in an ethical grey area, then you should consult with me *before* acting.

Detailed topical outline

- Multi-variable calculus
  - Implicit functions
  - Functional dependence
  - Coordinate transformation
  - Maxima and minima
  - Lagrange multipliers
- First-order differential equations
  - Separation of variables
  - Homogeneous equations
  - Exact equations
  - Integrating factors
  - Bernoulli equation
  - Riccati equation
  - Reduction of order
  - Uniqueness
  - Clairaut equation
- Linear differential equations
  - Linearity and linear independence
  - Complementary functions for equations with constant coefficients
  - Complementary functions for equations with variable coefficients
  - Particular solutions
- Series solution methods
  - Power series
  - Perturbation methods
  - Functional equations
- Special functions
  - Sturm-Liouville equations
  - Representation of arbitrary functions
- Vectors and tensors
  - Cartesian index notation
  - Cartesian tensors

  - Algebra of vectors
  - Calculus of vectors
  - Line and surface integrals
  - Differential operators
  - Special theorems
  - Orthogonal curvilinear coordinates

- Linear analysis
  - Sets
  - Differentiation and integration
  - Vector spaces
  - Operators
  - Equations
  - Method of weighted residuals

- Linear algebra
  - Determinants and rank
  - Matrix algebra
  - Orthogonal and unitary matrices
  - Matrix decompositions
  - Projection matrix
  - Method of least squares
  - Matrix exponential
  - Quadratic form
  - Moore-Penrose inverse

- Dynamical systems
  - Paradigm problems
  - Iterated maps
  - High order scalar differential equations
  - Linear systems
  - Nonlinear equations
  - Fractals
  - Bifurcations
  - Lorenz equations