**ENG EK 501 Mathematical Methods I**

**Course Description:** Mathematical methods I and II (501 & 502) present mathematical methods and concepts which are widely used in science and engineering. Unifying and/or geometric concepts are emphasized while stressing representative applications. The first course emphasizes calculus, linear algebra and ordinary differential equations (see course content below), while the second course emphasizes partial differential equations and numerical methods.

**Status in the Curriculum: Elective**

**Class/Lab Schedule**:
LEC: 4hrs/wk

**Textbooks and other required materials:**
**"All the Mathematics You Missed- But need to Know for Grad School"**, Thomas A. Garrity, Cambridge University Press, 2001- Available in the BU bookstore. ($9^{th}$ printing was in 2005, and so ISBN numbers can be hard to follow).
**"Schaum's Outline of Complex Variables"**, M. R. Spiegel, the McGraw-Hill Book Companies, (ISBN 0070602301).

The following books were once required for the course, and now serve as references.

- C.H. Edwards, Advanced Calculus of Several Variables, Dover, 1973,ISBN: 0-486-68336-2
- K. Yoshida, Lectures on Differential and Integral Equations, Dover, 1991, ISBN: 0-486-66679-4
- Golub & VanLoan, Matrix Computations, Johns Hopkins, 3rd ed., 1996, ISBN: 0801854148
- N. Young, An Introduction to Hilbert Space, Camb. U. P., 1998, ISBN: 0-521-337178
- The Mathworks, MATLAB-Student ed., documentation.

**Coordinator:** Robert Kotiuga, ECE

**Prerequisites:** Previous exposure to univariable calculus, linear algebra, vector calculus, ordinary differential equations, complex variable methods, and transform methods.

**Goals and Outcomes:**

1. Present linear algebra in a manner consistent with practices in scientific computing.
2. Develop vector calculus and complex variables in a conceptually coherent manner.
3. Develop a broader appreciation of the research that goes on in their department, and the college.
4. Instill an appreciation of life-long learning in the context of mathematics and engineering.

5. Besides developing a competence in the lecture material, complete an in depth study of how mathematics is used in the context of research or personal interests.

| **Program**: | **a** | **b** | c | d | e | f | g | h | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course**: | 1-5 | 5 | - | - | 1-5 | 3 | 4 | 3-5 | 4 | 1-5 | 1-5 |
| **Emphasis**: | 5 | 1 | 2 | 1 | 5 | 1 | 4 | 2 | 5 | 4 | 5 |

**Topics:**
At least two weeks will be spent on each of the first four sections below. Emphasis on remaining three sections will be dictated by the needs of the class:

- A development of the notions of numbers and polynomials which sets the stage for many involved results and applications of the course material. Some algorithmic themes will be developed in this context.
- Univariable calculus: review of basic techniques with an emphasis on algebraic and computational aspects such as rational functions and Pade approximations.
- Linear algebra: basic properties of linear systems, solution of linear systems by both direct and iterative methods, sparse matrices, inner product spaces, condition numbers, Krylov subspaces, eigenvalue and singular value decompositions, normal matrices, functions of matrices, structured (circulant, Hankel and Toeplitz) matrices.
- Multivariable calculus: multivariable Taylor approximations and critical point theory, implicit and inverse function theorems, fundamental theorem of multivariable (vector) calculus.
- Complex variable methods: Cauchy-Riemann equations, analytic functions, conformal mapping, positive real functions, analytic extension, Cauchy's theorem, the principle of the argument, special functions.
- Ordinary differential equations: Emphasis will be on aspects which reinforce concepts from linear algebra; systems of linear differential equations and Sturm-Liouville theory.
- Fourier, Hilbert and Laplace transform methods: Emphasis will be on complex inversion formulas and applications to systems theory (causality, passivity, Nyquist stability), Poisson resummation (sampling theorem), and integral equations.

**Contribution of Course to Meeting the Professional Component**:
Engineering topics: 100%

**Prepared by:** Robert Kotiuga **Date:** 6/11/09