ENGR 520 – Mathematical Analysis for Graduate Students (3 credits – 3 contact hours)

Course Description: The objective of this course is to provide an introduction to the mathematical methods that will be needed in subsequent graduate-level courses in engineering. Emphasis is placed on understanding the concepts for solving first- and second-order differential equations (ODEs), as opposed to extricating an answer from math packages such as Mathematica or MATLAB. The philosophy of understanding the underlying concepts of the math is emphasized throughout the course and is extended to the concept of integration in the complex plane and the origination of the Fourier/Laplace transforms as well as their inverse transforms. Additionally, various special functions are examined including: Gamma, Beta, Bessel, and Legendre (and associated) polynomials. The process of separation of variables in partial differential equations (PDEs) is covered in the three major coordinate systems with application to the Laplace, heat, and wave equations.

Textbook: Arfken, G. B., Weber, H. J. & Harris, F. E. (2012) *Mathematical Methods for Physicists (7th Edition): A Comprehensive Guide*. Academic Press.

Topics Covered:

- First-order ODEs
- Second-order ODEs, Wronskian
- Power series solutions, Bessel functions, Legendre polynomials
- Convergence, regular and essential singularities
- Method of Frobenius, associated Legendre equation
- Integration techniques, complex Z- and W-planes, multi-valued functions and branch cuts
- Cauchy-Riemann equations, deformation of contours, integration about a singularity
- Taylor and Laurent expansions of f(z), Jordan's lemma, Gamma and Beta functions
- Fourier series solutions for periodic functions, Fourier and inverse Fourier transforms
- Laplace and inverse Laplace transforms
- Classification of PDEs
- Separation of variables in Cartesian, cylindrical, and spherical coordinates
- Solution of model equations: Laplace's, wave and heat equations
- Extended discussion of Bessel functions to include development of second solutions, asymptotic representations, Hankel functions (cylindrical and spherical)

Contributions to the Professional Component: This graduate level engineering mathematics class develops the core competency of mathematics needed for a graduate-level study of electrical, mechanical, civil, chemical, computer, or biomedical engineering in subsequent applied courses. This class contains a thorough review of solutions for differential equations. Integration into the complex plane is introduced and developed with connections made to inverse Fourier and Laplace transforms. Fourier and Laplace transforms are developed from first principles so that the underpinnings of the theory are clear and students have a deeper understanding of the concepts and are not simply solving equations using tables of transforms. Separation of variables in the three major coordinate systems is developed from first concepts and applied to practical engineering equations such as the Laplace, wave, and diffusion equations.

Relationship of the course to Program Objectives: This course attempts to meet the stated departmental objectives:

1. An appreciation of the mathematical tools needed for graduate engineering studies
2. A working knowledge of advanced mathematical techniques

Expected Learning Outcomes: Upon completion of the course, students should be able to:

- CO-1: Solve first- and second-order differential equations
- CO-2: Solve differential equations using power series
- CO-3: Work with integration techniques using the complex plane
- CO-4: Work with the Gamma and Beta functions
- CO-5: Develop Fourier and Laplace transforms and inverse transforms
- CO-6: Work with separation of variables applied to solving differential equations

Course Outcome/ABET Outcome Matrix: The Matrix below shows how this course contributes covers the 11 ABET Outcomes.

	ABET 01	ABET 02	ABET 03	ABET 04	ABET 05	ABET 06	ABET 07	ABET 08	ABET 09	ABET 10	ABET 11
CO-1	X		X	X	X	X					X
CO-2	X		X	X	X	X					X
CO-3	X		X	X	X	X					X
CO-4	X		X	X	X	X					X
CO-5	X		X	X	X	X					X
CO-6	X		X	X	X	X					X

Outcome Assessment: The course employs the following mechanisms to assess the above learning outcomes:

1. Homework is assigned and graded weekly to assess the level of student understanding of topics covered during the week. The learning outcomes are also exhibited through the results of the several exams given during the semester and the final examination.
2. The instructor frequently asks students if they understand the lectures.
3. The overall assessment of the course is done through the university's Student Course Evaluation process.

Process of Improvement: The instructor continuously tries to improve the course as described as follows:

1. The instructor frequently evaluates the student performance on homework and exams, and reviews the suggestions made by students during the semester. Then the instructor takes proper steps (such as different approaches to difficult material) to correct problems.
2. The instructor is available after class for additional discussion.
3. At the end of each semester, the instructor meets with the chairman to discuss improvement plans for the course based on the university's Student Course Evaluation process

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