I. GENERAL DESCRIPTION
A. Approval Date: April 2014
B. Department: Mathematics
C. Course Number: MATH 125
D. Course Title: Differential Equations
E. Course Outline Preparer(s): Glenn Aguiar, Matthew Bertens, John Verosky
F. Department Chair: Dennis Piontkowski
G. Dean: David Yee

II. COURSE SPECIFICS
A. Hours: Lecture: 3 weekly (52.5 total)
B. Units: 3
C. Prerequisites: MATH 110C
   Corequisites: None
   Advisories: None
D. Course Justification: This subject is an extension of calculus and forms the mathematical basis of many physical theories. It is intended and usually required for mathematics, computer science, engineering, and physical science majors.
E. Field Trips: No
F. Method of Grading: Letter
G. Repeatability: 0

III. CATALOG DESCRIPTION
Ordinary differential equations and first order linear systems of differential equations; methods of explicit solution; qualitative methods for the behavior of solutions; theoretical results for the linear structure, existence, and uniqueness of solutions.

IV. MAJOR LEARNING OUTCOMES
Upon completion of this course a student will be able to:
A. Synthesize different viewpoints of first order differential equations.
B. Solve second order linear differential equations and apply them to physical models.
C. Apply the existence and uniqueness theorems for ordinary differential equations.
D. Generalize the ideas used in single differential equations to first order systems of differential equations.
E. Formulate series solutions of linear differential equations, especially in the case of non-constant coefficients.
F. Use the Laplace transform to solve differential equations.
G. Use Fourier series to solve classical partial differential equations, for example, the heat equation and the wave equation in one or more dimensions.
V. CONTENTS
A. First order differential equations
1. Basic concepts of differential equations
   a. Definition of a differential equation
   b. Solution of a differential equation
   c. Classification of differential equations
   d. Initial value problems
2. Methods of solution
   a. Separable equations
   b. Linear equations
   c. Exact equations
   d. Special types of equations
3. Qualitative methods
   a. Slope fields
   b. Phase lines
   c. Long term behavior
4. Theoretical concepts
   a. Existence of solutions
   b. Uniqueness of solutions
   c. Domain of definition of solutions
   d. Construction of numerical solutions
5. Applications
   a. Population models
   b. Heating and cooling
   c. Mixing
   d. Orthogonal trajectories
   e. Motion
B. Second order and higher order linear differential equations
1. Linear second order differential equations
   a. Linear independence of solutions and the Wronskian
   b. Linear combinations of solutions of the associated homogeneous equation
2. Constant coefficient second order differential equations
   a. The characteristic equation and its three types of roots
   b. Nonhomogeneous equations, including the methods of undetermined coefficients and variation of parameters
3. Higher order linear differential equations
   a. Extending the results in the second order case to higher order linear differential equations
4. Applications
   a. Mechanical vibrations
   b. Electrical circuits
   c. Periodic forcing function and resonance
C. Existence and uniqueness theorems
1. First order differential equations
   a. Apply theorems to linear and nonlinear first order initial value problems
2. Second order differential equations
a. Apply theorems to linear second order initial value problems
b. Use theorems to establish the general solution of a linear second order homogeneous equation

3. Higher order linear differential equations
a. Generalize results for second order linear differential equations to higher order linear differential equations

D. First order systems of differential equations
1. Constant coefficient 2x2 systems
   a. Solutions based on the eigenvalues and eigenvectors of the 2x2 constant coefficient matrix
   b. Phase plane diagrams of solutions
   c. Transforming second order differential equations in one variable to two first order differential equations
2. Non-Linear Systems
   a. Phase plane diagrams and the method of nullclines
   b. Linearization near an equilibrium point
   c. The Jacobian matrix

E. Series solutions
1. Review of power series
2. Constructing series solutions at an ordinary point
3. Distinguishing ordinary and regular singular points and their effects on the series solution method
4. The method of Frobenius

F. Laplace Transform
1. The basic ideas of the Laplace Transform
   a. Definition as an integral operator
   b. Transforming basic functions
   c. Transforming derivatives
   d. A table of Laplace transforms including shifting formulas
2. Solving constant coefficient differential equations
   a. Transforming a differential equation into an algebraic equation
   b. The inverse Laplace transform
3. Applications to discontinuous forcing functions
   a. The Heaviside function
   b. Other discontinuous functions

G. Fourier Series and Partial Differential Equations
1. Fourier, sine, and cosine series
2. Convergence behavior
3. Separation of variables and fundamental solutions of the heat, wave, and Laplace's partial differential equations
4. Solution of initial-boundary value problems

VI. INSTRUCTIONAL METHODOLOGY
A. Assignments
   1. In-class assignments: discussion, individualized work, or small group work appropriate to the day's lesson
   2. Out-of-class assignments

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a. Regular reading assignments for the material being covered in class
b. Regular homework that provides students with review and practice on the topics and procedures taught such as integrating factors, separation of variables, and variation of parameters
c. Group work may be required at the discretion of the instructor

B. Evaluation
1. Assignments as described above
2. Periodic exams that assess each student's proficiency in topics such as solving first and second order initial value problems, identifying and solving exact equations, and constructing numerical approximations to solutions of differential equations
3. A comprehensive final examination in key topics such as applying second order linear differential equations with constant coefficients to physical modeling, series solution methods for ordinary points and regular singular points, and Laplace transforms

C. Textbooks and other instructional materials
1. Textbook
   b. See the Mathematics Department's textbook list for the current textbook
2. Other Instructional Materials
   a. A scientific calculator or graphing calculator may be required
   b. Computer software and Internet access may be required for numerical calculations and qualitative analysis
   c. Instructor developed notes or supplementary exercises

VII. TITLE 5 CLASSIFICATION
CREDIT/DEGREE APPLICABLE (meets all standards of Title 5, Section 55002(a)).