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Course Outline for MATH 5

ORDINARY DIFFERENTIAL EQUATIONS

Effective: Spring 2018

I. CATALOG DESCRIPTION:
MATH 5 — ORDINARY DIFFERENTIAL EQUATIONS — 3.50 units

Introduction to differential equations including the conditions under which a unique solution exists, techniques for obtaining solutions, and applications. Techniques include generation of series solutions, use of Laplace Transforms, and the use of eigenvalues to solve linear systems. Generation of exact solutions, approximate solutions, and graphs of solutions using MATLAB.

3.00 Units Lecture 0.50 Units Lab

Prerequisite
MATH 3 - Multivariable Calculus
with a minimum grade of C

Grading Methods:
Letter Grade

Discipline:
- Mathematics

	MIN
Lecture Hours:	54.00
Lab Hours:	27.00
Total Hours:	81.00

II. NUMBER OF TIMES COURSE MAY BE TAKEN FOR CREDIT: 1

III. PREREQUISITE AND/OR ADVISORY SKILLS:
Before entering the course a student should be able to:

A. MATH3
   1. Extend the concepts of limits, continuity, differentiability and differential of single variable functions to functions of two or more variables;
   2. Compute limits, partial derivatives, total differential, gradient, directional derivatives and interpret them geometrically and in terms of rate of change;
   3. Apply partial derivatives and/or gradients to problems involving tangent planes and linear approximation, and optimization, especially using Lagrange multipliers;
   4. Compute double and triple integrals directly or using change of variables and explain the geometric interpretation of Jacobians;
   5. Apply differential operators, gradient, divergence, curl and Laplacian to scalar and vector field and interpret the results;
   6. Find scalar potentials for conservative vector fields.

IV. MEASURABLE OBJECTIVES:
Upon completion of this course, the student should be able to:

A. Create and analyze mathematical models based on ordinary differential equations;
B. Verify that a given solution satisfies a given differential equation and interpret it geometrically when appropriate;
C. Recognize certain types of differential equations and choose an appropriate method for obtaining a solution(s) in the following categories:
   1. First order equations
   2. Separable equations
   3. Exact equations
   4. First order linear equations
   5. Second order linear equations with constant coefficients
   6. Cauchy-Euler equations
   7. Higher order equations
   8. Nonlinear equations
D. Determine the existence of a unique solution to a first order differential equation;
E. Use a Wronskian to verify that a set of solutions is a fundamental set;
F. Solve systems of linear ordinary differential equations using eigenvalues;
G. Use MATLAB to

1. Find and plot exact solutions to ordinary differential equations
2. Plot directional fields
3. Approximate solutions using numerical methods
4. Produce a phase plane portrait
5. Generate coefficients for a series solution
6. Find eigenvalues and diagonalize matrices

V. CONTENT:

A. Introduction
   1. Classification and some origins of differential equations
   2. Geometric interpretation of equations and solutions
   3. Definitions and examples of initial value problems and boundary value problems

B. First order equations
   1. Separable
   2. Homogeneous
   3. Exact
   4. Linear
   5. Nonlinear
   6. Bernoulli
   7. Applications
      a. Exponential growth/decay
      b. Cooling
      c. Mixture problems
      d. Circuits

C. Higher order linear differential equations
   1. Homogeneous
   2. Fundamental set of solutions
      a. Wronskian
      b. Principle of superposition
      c. General solutions
   3. Nonhomogeneous
      a. Undetermined coefficients
      b. Variation of parameters
   4. Reduction of order
   5. Applications
      a. Mass-spring systems
      b. RLC Circuits
   6. Cauchy-Euler equations

D. Laplace Transforms
   1. Definition
      a. Piecewise continuous functions
      b. Functions of exponential order
   2. Properties
   3. Convolution
   4. Heaviside function
   5. Periodic functions
   6. Dirac delta function

E. Series solutions
   1. Ordinary points
   2. Regular singular points
   3. Bessel’s Equation

F. Systems of linear differential equations
   1. Distinct real eigenvalues and diagonalization
   2. Repeated eigenvalues
   3. Complex eigenvalues
   4. Fundamental matrices

G. Phase plane

H. MATLAB
   1. Symbolic integration
   2. Differentiation
   3. Numerical integration
   4. Euler’s Method
   5. Improved Euler’s method
   6. Classical 4th order Runge-Kutta method
   7. Picard’s Method
   8. Graphing
   9. Plotting directional fields
   10. Generating phase plane portraits
   11. Partial fraction expansions
   12. Laplace and inverse Laplace transforms of functions
   13. Eigenvalues
   14. Diagonalization
   15. Taylor Series
   16. Recurrence relations

VI. METHODS OF INSTRUCTION:

A. **Lecture** -
B. **Discussion** -
C. Web or CD-Rom based tutorials
D. Student presentations
E. **Lab** - Assignments
F. Colaborative learning

VII. TYPICAL ASSIGNMENTS:

A. Homework
   1. Homework should be assigned from the text and should include a sufficient number and variety of problems to develop both skill and conceptual understanding. Problems should range in level of difficulty from introductory level to challenging. A typical assignment should take an average student 1 to 2 hours for each hour in class B.

B. Collaborative learning

1. Collaborative learning, done in small groups of 2-4 students, can be used to introduce new concepts, build skills, or teach problem solving. Students may be asked to present their results on the board.
2. Example: Give each group a mass-spring system with initial conditions and ask them to find the equation of motion. Then have the group present their results to the class.

C. Laboratory assignments

1. Laboratory assignments can be used to reinforce fundamental concepts and skills, to explore certain concepts in more depth than is possible in-class, and to solve numerically challenging problems. They may be designated for individual or group work.
2. Example: Write an m-file in MATLAB which executes the classical 4th order Runge-Kutta algorithm for any first order ODE given any step size, initial condition, and time interval.

VIII. EVALUATION:

A. **Methods**

1. Exams/Tests
2. Projects
3. Group Projects
4. Home Work
5. Lab Activities

B. **Frequency**

1. Recommend minimum of three exams plus the final
2. Homework should be assigned for each section covered
3. Recommend minimum of nine laboratory assignments over the semester
4. Number of projects and collaborative activities are at the discretion of the instructor

IX. TYPICAL TEXTS:

1. Nagle, K.R., Saff, E.B., & Snider, A.D. (2017). *Fundamentals of Differential Equations* (9th ed.). Boston, MA: Addison-Wesley.
2. Zill, D.G. (2018). *A First Course in Differential Equations with Modeling Applications* (11th ed.). Boston, MA: Cengage Learning.
3. Simmons, G.F. (2017). *Differential Equations wtih Applications and Historical Notes* (3rd ed.). Boca Raton, FL: CRC Press.

X. OTHER MATERIALS REQUIRED OF STUDENTS: