Differential Equations

SECTION I: Course Overview

Course Code: MATH350PRG
Subject Area(s): Mathematics
Prerequisites: See below
Language of Instruction: English
Total Contact Hours: 60
Recommended Credits: 4

COURSE DESCRIPTION

In this course, you will cover material related principally to differential equations dealing with ordinary differential equations. These mathematics are an important tool in Science and Engineering and are commonly associated with understanding population dynamics, radioactive decay, and certain chemical reactions. The content of this course will thus focus on first-order differential equations, higher-order differential equations, Laplace transforms, and series solutions of linear differential equations.

In addition to the cognitive and knowledge skills listed above, students in this course will identify the relevance and practical applications of mathematics to various fields.

LEARNING OBJECTIVES

Upon successful completion of this course, you will be able to:

- Compute solutions of linear, 1st order, and higher-order differential equations.
- Solve linear differential equations with and without Power Series.
- Identify the Laplace transform of a given function.
- Interpret mathematical and/or logical modes such as formulas, graphs, tables, and schematics.

PREREQUISITES

Before enrollment, this course requires you to have completed course work in calculus III.

SECTION II: Instructor & Course Details

INSTRUCTOR DETAILS

Name:	TBD
Contact Information:	TBD
Term:	SUMMER

GRADING & ASSESSMENT

The instructor will assess your progress towards the above-listed learning objectives by using the forms of assessment below. Each of these assessments is weighted and will count towards your final grade. The following section (Assessment Overview) will provide further details for each.

Engagement	**20%**
Homework	**40%**
Midterm Examination	**20%**
Final Examination	**20%**

ASSESSMENT OVERVIEW

This section provides a brief description of each form of assessment listed above. Your course instructor will provide further details and instructions during class time.

Engagement (20%): Engagement in class is expected of all CEA CAPA students. Guidelines for engagement can be found on the list of academic policies.

Homework (40%): Homework is assigned at every class to be handed in as indicated on the syllabus. You must show all of your work. No late homework will be accepted.

Midterm Exam (20%): One midterm exam will be given during around the 13th session of class.

Final Examination (20%): A comprehensive final examination will be administered at the conclusion of the term.

ACTIVE LEARNING

CEA CAPA courses are designed to include a variety of active learning component that will take you out of the classroom and allow you to explore your local, host city. This course includes:

- Technical Museum

REQUIRED READINGS

The reading assignments for this course are listed below. All required readings must be completed according to the due date assigned by the course instructor. You will not need to purchase these readings; the instructor will provide these selected readings to you in class (either in paper or electronic format) and/or through CEA CAPA's online Moodle classroom.

SELECTED READING(S): The selected readings for this course are listed below. You will not need to purchase these readings; the instructor will provide these selected readings to you in class (either in paper or electronic format).

- Dennis G. Zill *Differential Equations with Boundary-Value Problems*. 9th ed.

KEY RESOURCES

In order to ensure your success abroad, CEA CAPA has provided the academic resources listed below.

- **UNH Online Library**: As a CEA CAPA student, you will be given access to the online library of the University of New Haven (UNH). You may access the UNH online library here. You must comply with UNH Policies regarding library usage.

- **CEA CAPA Classroom – Moodle**

COURSE CALENDAR *Differential Equations*			
SESSION	**TOPICS**	**ACTIVITY**	**STUDENT ASSIGNMENTS**
1	**Course Introduction:** Review Syllabus, Classroom Policies **Ch 1 – Introduction to Differential Equations**	Lecture and In-Class Problem Solving: **1.1 Definitions and Terminology** – *Notation, Classification by Type, Order, and Linearity, Solution Curves, Explicit or Implicit Solutions, Systems of Diff Eq.* **1.2 Initial-Value Problems** – *Types of IVPs, Geometric interpretation of IVPs, Existence of Unique Solution* **1.3 Differential Equations as Mathematical Models** – *Population Dynamics, Radioactive Decay, Newton's Law of Cooling/Warming, Chemical Reactions, Mixtures, Series Circuits, Falling Bodies, Air Resistance*	**Readings:** Zill, Chapter 1
2	**Review of Ch. 1** **Ch 2 – First-Order Differential Equations**	Lecture and In-Class Problem Solving: **2.1 Solution Curves Without a Solution** – *Direction Fields, Autonomous First-Order DEs, Critical Points, Stability, Revise Mathematical Models* **2.2 Separable Equations** – *Solutions by Integration, Solution Curves, IVPs, Solutions Defined by Integrals, Revise Mathematical Models*	**Readings:** Zill, Chapter 2 Homework 1 issued
3	**Ch 2 – First-Order Differential Equations**	Lecture and In-Class Problem Solving: **2.3 Linear Equations** – *Method of Solution: Integration Factor* **2.5 Solutions by Substitutions** – *Homogeneous Equations, Bernoulli's Equation, Reduction to Separation of Variables*	**Readings:** Zill, Chapter 2 Homework 2 issued (Integration Factor)

4	**Ch 2 – First-Order Differential Equations** **Ch 9 – Numerical Solutions of ODEs**	Lecture and In-Class Problem Solving: **2.6 A Numerical Method** – *Using the Tangent Line, Euler's Method, Numerical Solvers* **9.1 Euler Methods and Error Analysis** – *Errors in Numerical Methods, Truncation Errors for Euler's Method, Improved Euler's Method, Truncation Errors for Improved Euler's Method*	***Homework 1 Due** **Readings:** Zill, Chapter 2, Chapter 9.1
5	**Ch 3 – Modeling with First-Order Differential Equations**	Lecture and In-Class Problem Solving: **3.1 Linear Models** – *Growth and Decay, Carbon Dating, Newton's Law of Cooling/Warming, Mixtures, Series Circuits, Air Resistance, the Sliding Box* **3.2 Nonlinear Models** – *Population Dynamics, Logistic Equation, Chemical Reactions, Leaking Tank, Project Problems (least squares, regression)* **3.3 Modeling with Systems of First-Order DEs** – *Linear/Nonlinear Systems, Matrix Notation, Predator-Prey, Mixtures, Competition Models, Project Problems*	**Readings:** Zill, Chapter 3, Chapter 8.1 Homework 3 issued (Linear models) Homework 4 issued (System models)
6	**Ch 4 – Higher-Order Differential Equations**	Lecture and In-Class Problem Solving: **4.1 Preliminary Theory of Linear Equations** – *IVPs and BVPs, Existence and Uniqueness, Homogeneous/Nonhomogeneous Equations, Differential Operators, Superposition Principle, Linear Dependence/Independence, the Fundamental Set of Solutions, the Wronskian, the General Solution for Homogeneous Equations, the General Solution for Nonhomogeneous Equations* **4.2 Reduction of Order** – *Substitution, Finding a Second Solution*	***Homework 2 Due** **Readings:** Zill, Chapter 4
7	**Ch 4 – Higher-Order Differential Equations**	Lecture and In-Class Problem Solving: **4.3 Homogeneous Linear Equations with Constant Coefficients**– *Auxillary/Characteristic Equation, Distinct Real Roots, Repeated Roots, Conjugate Complex Roots, Higher-Order DEs* **4.4 Undetermined Coefficients, the Superposition Approach** – *the General Solution, the Particular Solution, Glitches in the Method, Higher-Order DEs*	**Readings:** Zill, Chapter 4

8	**Ch 4 – Higher-Order Differential Equations**	Lecture and In-Class Problem Solving: **4.6 Variation of Parameters** – *Linear First-Order DEs Revisited, Linear Second-Order DEs* **4.7 Cauchy-Euler Equation** – *Distinct Roots, Repeated Roots, Conjugate Complex Roots* **4.8 Green's Functions** –*Input, Output, Forcing Function, IVPs, BVPs*	***Homework 3 Due** **Readings:** Zill, Chapter 4 Homework 5 issued (2nd Order equations) Homework 6 issued (Green functions)
9	**Ch 4 – Higher-Order Differential Equations** **Ch 8 – Systems of Linear First-Order Differential Equations**	Lecture and In-Class Problem Solving: **4.9 Solving Systems of Linear DEs by Elimination**– *Systematic Elimination* **8.2 Homogeneous Linear Systems** – *Distinct Real Eigenvalues, Phase Portrait, Repeated Eigenvalues, Multiplicity, Complex Eigenvalues*	**Readings:** Zill, Chapter 4, Chapter 8.2
10	**Ch 5 – Modeling with Higher-Order Differential Equations**	Lecture and In-Class Problem Solving: **5.1 Linear Model: Initial Value Problems**– *Spring/Mass Systems: Free Undamped Motion, Free Damped Motion, Driven Motion* **5.2 Linear Models: Boundary Value Problems** – *Deflection of a Beam, Eigenvalues and Eigenfunctions, Euler Loads*	**Readings:** Zill, Chapter 5 Homework 7 issued (initial and boundary value problems)
11	**Ch 5 – Modeling with Higher-Order Differential Equations**	Lecture and In-Class Problem Solving: **4.10 Nonlinear Differential Equations**– *Reduction of Order, Missing dependent variable* **5.3 Nonlinear Models**– *Nonlinear Springs, Pendulums, Rocket Motion, Variable Mass, Miscellaneous Models*	***Homework 4 Due** ***Homework 5 Due** **Readings:** Zill, Chapter 5, Chapter 4.10 Homework 7 issued (Non-linear models)
12	**Midterm review**	Lecture and In-Class Problem Solving: **Midterm Review Chapters 1 - 5**	**Readings:** Zill, Chapters 1-5, 9.1, 8.1 – 8.2

13	**MIDTERM EXAMINATION**		
14	**Ch 6 – Modeling with Higher-Order Differential Equations**	Lecture and In-Class Problem Solving: **6.1 Power Series Review**– *Convergence, Interval of Convergence, Radius of Convergence, Maclaurin Series, Operations with Power Series* **6.2 Solutions about Ordinary Points**– *What is an Ordinary Point? Singular Point? Existence of a Power Series Solution, Minimum Radius of Convergence, Recurrence relation*	**Readings:** Zill, Chapter 6
15	**Ch 6 – Modeling with Higher-Order Differential Equations**	Lecture and In-Class Problem Solving: **6.3 Solutions about Singular Points–** *What is a Regular Singular Point? Irregular Singular Point? Frobenius' Theorem, the Indicial Equation, Modeling Examples* **6.4 Special Functions–** *Bessel Functions, Legendre's Equation and Polynomials*	***Homework 6 Due** ***Homework 7 Due** Homework issued 8 (power series and solutions) **Readings:** Zill, Chapter 6
16	**Ch 7 – The Laplace Transform**	Lecture and In-Class Problem Solving: **7.1 Definition of the Laplace Transform–** *Transforms of Some Basic Functions, Existence, Transform of a Piecewise function* **7.2 Inverse Transforms and Transforms of Derivatives–** *Some Inverse Transforms, Review of Partial Fractions, Transforming Differential Equations* **7.3 Operational Properties I–** *Translation on the s-Axis, Translation on the t-Axis, Applications to Beam Theory*	**Readings:** Zill, Chapter 7

17	**Ch 7 – The Laplace Transform**	Lecture and In-Class Problem Solving: **7.4 Operation Properties II–** *Derivatives of a Transform, Transforms of Integrals, Transform of a Periodic Function* **7.6 Systems of Linear Differential Equations–** *Coupled Springs, Double Pendulum, Electrical Networks* **8.3 Nonhomogeneous Linear Systems–** *Using Laplace Transforms*	***Homework 8 Due** **Readings:** Zill, Chapter 7, 8.3 Homework 9 issued (Laplace transform)
18	**Ch 8 – Systems of Linear First-Order Differential Equations**	Lecture and In-Class Problem Solving: **8.3 Nonhomogeneous Linear Systems–** *Undetermined Coefficients, Variation of Parameters, Applications*	**Readings:** Zill, Chapter 8
19	**Ch 10 – Plane Autonomous Systems**	Lecture and In-Class Problem Solving: **10.1 Autonomous Systems–** *Definition, Vector Field Interpretation, Types of Solutions, Finding Critical Points* **10.2 Stability of Linear Systems–** *Stability Analysis, Eigenvalues and the Shape of Solutions, Real Distinct Eigenvalues, Repeated Eigenvalues, Complex Eigenvalues, Classifying Critical Points*	**Readings:** Zill, Chapter 10 Homework 10 issued
20	**FIELD STUDY**		
21	**Ch 10 – Plane Autonomous Systems**	Lecture and In-Class Problem Solving: **10.3 Linearization and Local Stability**– *Stable Critical Points, Unstable Critical Points, Stability Criteria for Plane Autonomous Systems, Stability Analysis of Nonlinear Systems* **10.4 Autonomous Systems as Mathematical Models**– *Nonlinear Pendulum, Bead Sliding Along a Sine Wave, PredatorPrey*	***Homework 9 Due** **Readings:** Zill, Chapter 10
22	**Ch 9 – Numerical Solutions of ODEs**	Lecture and In-Class Problem Solving: **9.2 Runge-Kutta Methods**– *Second-Order RK, Fourth-Order RK, Truncation Errors* **9.4 Higher-Order Equations and Systems**– *Euler's Method, RK4 Method*	***Homework 10 Due** **Readings:** Zill, Chapter 9

23	**Final review**	Lecture and In-Class Problem Solving: **Final Review Chapters 6 - 10**	
24	**FINAL EXAMINATION**		

SECTION III: CEA CAPA Academic Policies

To see all CEA CAPA academic policies outlined, please follow the following links. Students are expected to review and understand all CEA CAPA student policies, including the academic policies outlined online. CEA CAPA reserves the right to change, update, revise, or amend existing policies and/or procedures at any time.

Class & Instructor Policies can be found here
General Academic Policies can be found here