# *Differential Equations*

## SECTION I: Course Overview

**Course Code**: MATH350CDG
**Subject Areas**: Mathematics
**Prerequisites**: See below
**Language of Instruction**: English
**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

## ATTENDANCE POLICY

This class will meet four times weekly for 125 minutes each session for 24 sessions. All students are expected to arrive on time and prepared for the day's class session.

CEA enforces a mandatory attendance policy. You are therefore expected to attend all regularly scheduled class sessions, including any field trips, site visits, guest lectures, etc. that are assigned by the instructor. The table below shows the number of class sessions you may miss before receiving a grade penalty.

| ALLOWED ABSENCES – SUMMER | | |
|---|---|---|
| **Courses Meeting X day(s) Per Week** | **Allowed Absence(s)** | **Automatic Failing Grade at X$^{th}$ absence** |
| Courses meeting **4** day(s) per week | **1** Absence | **4$^{th}$** Absence |

For every additional absence beyond the allowed number, your final course grade will drop down to the subsequent letter grade (ex: A+ to A). As a student, you should understand that the grade penalties will apply if you are marked absent due to tardiness or leaving class early. In the table below, you will find the grade penalty associated with each excessive absence up to and including automatic course failure.

| ATTENDANCE DOCKING PENALTIES | | | | |
|---|---|---|---|---|
| **Absence** | **1$^{st}$** | **2$^{nd}$** | **3$^{rd}$** | **4$^{th}$** |
| **Penalty** | **No Penalty** | **0.5 Grade Docked** | **1 Grade Docked** | **Automatic Failure** |
| **HIGHEST POSSIBLE GRADE AFTER ATTENDANCE PENALTIES** | | | | |
| **Grade** | **A+** | **A** | **A-** | **F** |

CEA does not distinguish between excused and unexcused absences. As such, no documentation is required for missing class. Similarly, excessive absences, and the grade penalty associated with each, will not be excused even if you are able to provide documentation that shows the absence was beyond your control. You should therefore only miss class when truly needed as illness or other unavoidable factors may force you to miss a class session later on in the term.

## 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.

| | |
|---|---|
| **Class Participation** | **10%** |
| **Homework** | **30%** |
| **Midterm Examination** | **30%** |
| **Final Examination** | **30%** |

The instructor will calculate your course grades using the CEA Grading Scale shown below. As a CEA student, you should understand that credit transfer decisions–including earned grades for courses taken abroad–are ultimately made by your home institution.

| CEA GRADING SCALE | | | |
|---|---|---|---|
| **Letter Grade** | **Numerical Grade** | **Percentage Range** | **Quality Points** |
| A+ | 9.70 – 10.0 | 97.0 – 100% | 4.00 |
| A | 9.40 – 9.69 | 94.0 – 96.9% | 4.00 |
| A- | 9.00 – 9.39 | 90.0 – 93.9% | 3.70 |
| B+ | 8.70 – 8.99 | 87.0 – 89.9% | 3.30 |
| B | 8.40 – 8.69 | 84.0 – 86.9% | 3.00 |
| B- | 8.00 – 8.39 | 80.0 – 83.9% | 2.70 |
| C+ | 7.70 – 7.99 | 77.0 – 79.9% | 2.30 |
| C | 7.40 – 7.69 | 74.0 – 76.9% | 2.00 |
| C- | 7.00 – 7.39 | 70.0 – 73.9% | 1.70 |
| D | 6.00 – 6.99 | 60.0 – 69.9% | 1.00 |
| F | 0.00 – 5.99 | 0.00 – 59.9% | 0.00 |
| W | Withdrawal | N/A | 0.00 |
| INC | Incomplete | N/A | 0.00 |

## 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.

**Class Participation (10%):** Student participation is mandatory for all courses taken at a CEA Study Center. The instructor will use the rubric below when determining your participation grade. All students should understand that attendance and punctuality are expected and will not count positively toward the participation grade.

| CLASS PARTICIPATION GRADING RUBRIC | |
|---|---|
| **Student Participation Level** | **Grade** |
| You make major & original contributions that spark discussion, offering critical comments clearly based on readings, research, & theoretical course topics. | **A+** (10.0 – 9.70) |
| You make significant contributions that demonstrate insight as well as knowledge of required readings & independent research. | **A/A-** (9.69 – 9.00) |
| You participate voluntarily and make useful contributions that are usually based upon some reflection and familiarity with required readings. | **B+/B** (8.99 – 8.40) |
| You make voluntary but infrequent comments that generally reiterate the basic points of the required readings. | **B-/C+** (8.39 – 7.70) |
| You make limited comments only when prompted and do not initiate debate or show a clear awareness of the importance of the readings. | **C/C-** (7.69 – 7.00) |

| | |
|---|---|
| You very rarely make comments and resist engagement with the subject. You are not prepared for class and/or discussion of course readings. | **D** (6.99 – 6.00) |
| You make irrelevant and tangential comments disruptive to class discussion. You are consistently unprepared for class and/or discussion of the course readings. | **F** (5.99 – 0.00) |

**Homework (30%):** 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 (30%):** One midterm exam will be given during around the 13th session of class.

**Final Examination (30%):** A comprehensive final examination will be administered at the conclusion of the term.

## EXPERIENTIAL LEARNING ACTIVITIES (AICAP)

CEA courses are designed to include a variety of experiential learning activities that will take you out of the classroom and allow you to explore your local, host city. These activities may include field studies, guest lectures and/or activities offered through our Academically Integrated Cultural Activities Program (AICAP). Please check the Forms of Assessment section to find out if AICAP activities are related to any specific form of assessment. The following experiential learning activities are recommended for this course:

- Guided visits

## REQUIRED READINGS

Reading assignments for this course will come from the required text(s) and/or the selected reading(s) listed below. All required readings–whether assigned from the text or assigned as a selected reading–must be completed according to the due date assigned by the course instructor.

I. **REQUIRED TEXT(S)**: You may purchase the required text(s) prior to departure or upon program arrival. The required text(s) are listed below:

   Dennis G. Zill and Warren S. Wright. *Differential Equations with Boundary-Value Problems*. 8th ed., 2014.

## ADDITIONAL RESOURCES

In order to ensure your success abroad, CEA has provided the academic resources listed below. In addition to these resources, each CEA Study Center provides students with a physical library and study areas for group work. The Academic Affairs Office at each CEA Study Center also compiles a bank of detailed information regarding libraries, documentation centers, research institutes, and archival materials located in the host city.

- **UNH Online Library**: As a CEA student, you will be given access to the online library of CEA's School of Record, the University of New Haven (UNH). You can use this online library to access databases and additional resources while performing research abroad. You may access the UNH online library here or through your MyCEA Account. You must comply with UNH Policies regarding library usage.

- **CEAClassroom – Moodle**: CEA instructors use Moodle, an interactive virtual learning environment. This web-based platform provides you with constant and direct access to the course syllabus, daily schedule of class lectures and assignments, non-textbook required readings, and additional resources. Moodle includes the normal array of forums, up-loadable and downloadable databases, wikis, and related academic support designed for helping you achieve the learning objectives listed in this syllabus.

During the first week of class, CEA academic staff and/or faculty will help you navigate through the many functions and resources Moodle provides. While you may print a hard copy version of the syllabus, you should always check Moodle for the most up-to-date information regarding this course. The instructor will use Moodle to make announcements and updates to the course and/or syllabus. It is your responsibility to ensure that you have access to all Moodle materials and that you monitor Moodle on a daily basis in case there are any changes made to course assignments or scheduling.

To access Moodle: Please log-in to your MyCEA account using your normal username and password. Click on the "While You're Abroad Tab" and make sure you are under the "Academics" sub-menu. There you will see a link above your schedule that says "View Online Courses" select this link to be taken to your Moodle environment.

| COURSE CALENDAR<br>*Differential Equations* | | | |
|---|---|---|---|
| **SESSION** | **TOPICS** | **ACTIVITY** | **STUDENT ASSIGNMENTS** |
| **1** | **Course Introduction:**<br>Review Syllabus, Classroom Policies<br><br>**Ch 1 – Introduction to Differential Equations** | Lecture and In-Class Problem Solving:<br>**1.1 Definitions and Terminology** – *Notation, Classification by Type, Order, and Linearity, Solution Curves, Explicit or Implicit Solutions, Systems of Diff Eq.*<br>**1.2 Initial-Value Problems** – *Types of IVPs, Geometric interpretation of IVPs, Existence of Unique Solution*<br>**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:**<br>Zill & Wright, Chapter 1 |
| **2** | **Review of Ch. 1**<br><br>**Ch 2 – First-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**2.1 Solution Curves Without a Solution** – *Direction Fields, Autonomous First-Order DEs, Critical Points, Stability, Revise Mathematical Models*<br>**2.2 Separable Equations** – *Solutions by Integration, Solution Curves, IVPs, Solutions Defined by Integrals, Revise Mathematical Models* | **Readings:**<br>Zill & Wright, Chapter 2<br><br>Homework 1 issued |
| **3** | **Ch 2 – First-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**2.3 Linear Equations** – *Method of Solution: Integration Factor*<br>**2.4 Exact Equations** – *Differential of a two-variable function, Criterion for an Exact Equation, Method of Solution*<br>**2.5 Solutions by Substitutions** – *Homogeneous Equations, Bernoulli's Equation, Reduction to Separation of Variables* | **Readings:**<br>Zill & Wright, Chapter 2 |
| **4** | **Ch 2 – First-Order Differential Equations**<br>**Ch 9 – Numerical Solutions of ODEs** | Lecture and In-Class Problem Solving:<br>**2.6 A Numerical Method** – *Using the Tangent Line, Euler's Method, Numerical Solvers*<br>**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**<br><br>**Readings:**<br>Zill & Wright, Chapter 2, Chapter 9.1<br><br>Homework 2 issued |

*The instructor reserves the right to make changes or modification to this syllabus as needed*

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| **5** | **Ch 3 – Modeling with First-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**3.1 Linear Models** – *Growth and Decay, Carbon Dating, Newton's Law of Cooling/Warming, Mixtures, Series Circuits, Air Resistance, the Sliding Box*<br>**3.2 Nonlinear Models** – *Population Dynamics, Logistic Equation, Chemical Reactions, Leaking Tank, Project Problems (least squares, regression)*<br>**3.3 Modeling with Systems of First-Order DEs** – *Linear/Nonlinear Systems, Matrix Notation, Predator-Prey, Mixtures, Competition Models, Project Problems* | **Readings:**<br>Zill & Wright, Chapter 3, Chapter 8.1 |
| **6** | **Ch 4 – Higher-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**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*<br>**4.2 Reduction of Order** – *Substitution, Finding a Second Solution* | ***Homework 2 Due**<br>**Readings:**<br>Zill & Wright, Chapter 4<br>Homework 3 issued |
| **7** | **Ch 4 – Higher-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**4.3 Homogeneous Linear Equations with Constant Coefficients**– *Auxillary/Characteristic Equation, Distinct Real Roots, Repeated Roots, Conjugate Complex Roots, Higher-Order DEs*<br>**4.4 Undetermined Coefficients, the Superposition Approach** *– the General Solution, the Particular Solution, Glitches in the Method, Higher-Order DEs* | **Readings:**<br>Zill & Wright, Chapter 4 |
| **8** | **Ch 4 – Higher-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**4.6 Variation of Parameters** – *Linear First-Order DEs Revisited, Linear Second-Order DEs*<br>**4.7 Cauchy-Euler Equation** – *Distinct Roots, Repeated Roots, Conjugate Complex Roots*<br>**4.8 Green's Functions** –*Input, Output, Forcing Function, IVPs, BVPs* | ***Homework 3 Due**<br>**Readings:**<br>Zill & Wright, Chapter 4<br>Homework 4 issued |

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| **9** | **Ch 4 – Higher-Order Differential Equations**<br>**Ch 8 – Systems of Linear First-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**4.9 Solving Systems of Linear DEs by Elimination**– *Systematic Elimination*<br>**8.2 Homogeneous Linear Systems** – *Distinct Real Eigenvalues, Phase Portrait, Repeated Eigenvalues, Multiplicity, Complex Eigenvalues* | **Readings:**<br>Zill & Wright, Chapter 4, Chapter 8.2 |
| **10** | **Ch 5 – Modeling with Higher-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**5.1 Linear Model: Initial Value Problems**– *Spring/Mass Systems: Free Undamped Motion, Free Damped Motion, Driven Motion*<br>**5.2 Linear Models: Boundary Value Problems** – *Deflection of a Beam, Eigenvalues and Eigenfunctions, Euler Loads* | ***Homework 4 Due**<br>**Readings:**<br>Zill & Wright, Chapter 5<br>Homework 5 issued |
| **11** | **Ch 5 – Modeling with Higher-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**4.10 Nonlinear Differential Equations**– *Reduction of Order, Missing dependent variable*<br>**5.3 Nonlinear Models**– *Nonlinear Springs, Pendulums, Rocket Motion, Variable Mass, Miscellaneous Models* | **Readings:**<br>Zill & Wright, Chapter 5, Chapter 4.10 |
| **12** | **Midterm review** | Lecture and In-Class Problem Solving:<br>**Midterm Review Chapters 1 - 5** | ***Homework 5 Due**<br>**Readings:**<br>Zill & Wright, Chapters 1-5, 9.1, 8.1 – 8.2<br>Homework 6 issued |
| **13** | **MIDTERM EXAMINATION** | | |
| **14** | **Ch 6 – Modeling with Higher-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**6.1 Power Series Review**– *Convergence, Interval of Convergence, Radius of Convergence, Maclaurin Series, Operations with Power Series*<br>**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:**<br>Zill & Wright, Chapter 6 |

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| **15** | **Ch 6 – Modeling with Higher-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**6.3 Solutions about Singular Points–** *What is a Regular Singular Point? Irregular Singular Point? Frobenius' Theorem, the Indicial Equation, Modeling Examples*<br>**6.4 Special Functions–** *Bessel Functions, Legendre's Equation and Polynomials* | ***Homework 6 Due**<br>**Readings:**<br>Zill & Wright, Chapter 6 |
| **16** | **Ch 7 – The Laplace Transform** | Lecture and In-Class Problem Solving:<br>**7.1 Definition of the Laplace Transform–** *Transforms of Some Basic Functions, Existence, Transform of a Piecewise function*<br>**7.2 Inverse Transforms and Transforms of Derivatives–** *Some Inverse Transforms, Review of Partial Fractions, Transforming Differential Equations* | **Readings:**<br>Zill & Wright, Chapter 7 |
| **17** | **Ch 7 – The Laplace Transform** | Lecture and In-Class Problem Solving:<br>**7.3 Operational Properties I–** *Translation on the s-Axis, Translation on the t-Axis, Applications to Beam Theory*<br>**7.4 Operation Properties II–** *Derivatives of a Transform, Transforms of Integrals, Transform of a Periodic Function* | **Readings:**<br>Zill & Wright, Chapter 7<br>Homework 7 issued |
| **18** | **Ch 7 – The Laplace Transform** | Lecture and In-Class Problem Solving:<br>**7.6 Systems of Linear Differential Equations–** *Coupled Springs, Double Pendulum, Electrical Networks*<br>**8.3 Nonhomogeneous Linear Systems–** *Using Laplace Transforms* | **Readings:**<br>Zill & Wright, Chapter 7, 8.3 |
| **19** | **Ch 8 – Systems of Linear First-Order Differential Equations** | Lecture and In-Class Problem Solving:<br>**8.3 Nonhomogeneous Linear Systems–** *Undetermined Coefficients, Variation of Parameters, Applications* | ***Homework 7 Due**<br>**Readings:**<br>Zill & Wright, Chapter 8<br>Homework 8 issued |
| **20** | **Ch 10 – Plane Autonomous Systems** | Lecture and In-Class Problem Solving:<br>**10.1 Autonomous Systems–** *Definition, Vector Field Interpretation, Types of Solutions, Finding Critical Points*<br>**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:**<br>Zill & Wright, Chapter 10 |

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| **21** | **Ch 10 – Plane Autonomous Systems** | Lecture and In-Class Problem Solving:<br>**10.3 Linearization and Local Stability–** *Stable Critical Points, Unstable Critical Points, Stability Criteria for Plane Autonomous Systems, Stability Analysis of Nonlinear Systems*<br>**10.4 Autonomous Systems as Mathematical Models–** *Nonlinear Pendulum, Bead Sliding Along a Sine Wave, Predator-Prey* | ***Homework 8 Due**<br>**Readings:**<br>Zill & Wright, Chapter 10<br>Homework 9 issued |
| **22** | **Ch 9 – Numerical Solutions of ODEs** | Lecture and In-Class Problem Solving:<br>**9.2 Runge-Kutta Methods–** *Second-Order RK, Fourth-Order RK, Truncation Errors*<br>**9.4 Higher-Order Equations and Systems–** *Euler's Method, RK4 Method* | **Readings:**<br>Zill & Wright, Chapter 9 |
| **23** | **Final Review** | Lecture and In-Class Problem Solving:<br>**Final Review** | ***Homework 9 Due**<br>**Readings:**<br>Zill & Wright, Chapter 9<br>Homework 10 issued – due at Final Examination |
| **24** | **FINAL EXAMINATION** | | |

## SECTION III: CEA Academic Policies

The policies listed in this section outline general expectations for CEA students. You should carefully review these policies to ensure success in your courses and during your time abroad. Furthermore, as a participant in the CEA program, you are expected to review and understand all CEA Student Policies, including the academic policies outlined on our website. CEA reserves the right to change, update, revise, or amend existing policies and/or procedures at any time. For the most up to date policies, please review the policies on our website.

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