ILLINOIS VALLEY COMMUNITY COLLEGE

COURSE OUTLINE

DIVISION: Natural Sciences and Business

COURSE: MTH 2007 Differential Equations

Date: Spring 2022

Credit Hours: 3

Complete all that apply or mark "None" where appropriate:

Prerequisite(s): None

Enrollment by assessment or other measure? ☐ Yes ☒ No
If yes, please describe:

Corequisite(s): None

Pre- or Corequiste(s): MTH 2003

Consent of Instructor: ☐ Yes ☒ No

Delivery Method:

☒ **Lecture**	**3 Contact Hours**	**(1 contact = 1 credit hour)**
☐ **Seminar**	**0 Contact Hours**	**(1 contact = 1 credit hour)**
☐ **Lab**	**0 Contact Hours**	**(2-3 contact = 1 credit hour)**
☐ **Clinical**	**0 Contact Hours**	**(3 contact = 1 credit hour)**
☒ **Online**		
☒ **Blended**		
☒ **Virtual Class Meeting (VCM)**		

Offered: ☒ **Fall** ☒ **Spring** ☒ **Summer**

CATALOG DESCRIPTION and IAI NUMBER (if applicable):
Topics covered include solutions of ordinary differential equations, first order differential equations and the existence and uniqueness of their solutions, higher order differential equations with constant coefficients by exact methods, some equations with variable coefficients, systems of equations, Laplace transforms, and an introduction to numerical methods. Applications of all topics to problems arising in engineering and the physical sciences are studied. IAI equivalent: MTH 912

ACCREDITATION STATEMENTS AND COURSE NOTES:
None

COURSE TOPICS AND CONTENT REQUIREMENTS:

I. Introduction to Differential Equations
   A. Definitions and Terminology
   B. Initial-Value Problems
   C. Differential Equations as Mathematical Models

II. First-Order Differential Equations
   A. Separable Variables
   B. Exact Equations
   C. Linear Equations
   D. Solutions by Substitutions

III. Modeling with First-Order Differential Equations
   A. Linear Equations
   B. Nonlinear Equations
   C. Systems of Linear and Nonlinear Equations

IV. Differential Equations of Higher Order
   A. Preliminary Theory: Linear Equations
   B. Initial-Value and Boundary-Value Problems
   C. Homogeneous Equations
   D. Nonhomogeneous Equations
   E. Reduction of Order
   F. Homogeneous Linear Equations with Constant Coefficients
   G. Undetermined Coefficients – Superpostion Approach
   H. Variation of Parameters
   I. Cauchy-Euler Equations
   J. Nonlinear Systems

V. Modeling with Higher-Order Differential Equations
   A. Linear Equations: Initial-Value Problems
   B. Spring/Mass Systems: Free Undamped Motion
   C. Spring/Mass Systems: Free Damped Motion
   D. Spring/Mass Systems: Driven Motion
   E. Analogous Systems
   F. Linear Equations: Boundary-Value Problems
   G. Nonlinear Equations

VI. Series Solutions of Linear Equations
   A. Review of Power Series
   B. Power Series Solutions
   C. Solutions about Ordinary Points
   D. Solutions about Singular Points

VII. Laplace Transforms
- A. Definition of the Laplace Transform
- B. Inverse Transform
- C. Translations Theorems
- D. Derivatives of a Transform
- E. Transforms of Derivatives
- F. Transforms of Integrals
- G. Transforms of Periodic Functions
- H. Applications
- I. Systems of Linear Equations

VIII. Systems of Linear First-Order Differential Equations
- A. Preliminary Theory
- B. Homogeneous Linear Systems with Constant Coefficients
- C. Distinct Real Eigenvalues
- D. Repeated Eigenvalues
- E. Complex Eigenvalues
- F. Variation of Parameters

INSTRUCTIONAL METHODS:
1. Lecture
2. Class discussion
3. Tests and quizzes
4. Evaluation of class assignments
5. Use of audio-visual aids and graphing calculators
6. Supplemental handouts

EVALUATION OF STUDENT ACHIEVEMENT:
1. Homework (4% of grade)
2. Class participation
3. Regular attendance
4. Tests (71% of grade)
5. Quizzes (7%of grade)
6. Group exercises (4% of grade)
7. Final Exam (14% of grade)

INSTRUCTIONAL MATERIALS:
Textbooks
A First Course in Differential Equations with Modeling Applications, Zill, 11th edition, Brooks/Cole, 2018

Resources
None

LEARNING OUTCOMES AND GOALS:

Institutional Learning Outcomes

☐ 1) Communication – to communicate effectively;

☒ 2) Inquiry – to apply critical, logical, creative, aesthetic, or quantitative analytical reasoning to formulate a judgement or conclusion;

☐ 3) Social Consciousness – to understand what it means to be a socially conscious person, locally and globally;

☐ 4) Responsibility – to recognize how personal choices affect self and society.

Course Outcomes and Competencies

Upon completion of the course, the student will be able to:

1. Students will be able to demonstrate knowledge of the fundamental concepts of differential equations.
   - 1.1. Students will be able to identify the order and degree of an ordinary differential equation.
   - 1.2. Students will be able to classify a differential equation as either linear or nonlinear.
   - 1.3. Students will be able to verify that an indicated function is a solution of a given differential equation.
   - 1.4. Students will be able to determine a region of the xy-plane for which a given differential equation will have a unique solution through a point (x0, y0) in the region.
   - 1.5. Students will be able to construct suitable differential equations as mathematical models.

2. Students will be able to demonstrate knowledge of methods of solving some first-order differential equations.
   - 2.1. Students will be able to solve first-order differential equations by the method of separation of variables.
   - 2.2. Students will be able to solve first-order differential equations by the method of exactness.
   - 2.3. Students will be able to solve first-order differential equations by first finding an integrating factor.
   - 2.4. Students will be able to solve homogeneous differential equations by using a suitable substitution.
   - 2.5. Students will be able to solve Bernoulli equations by using a suitable substitution.

3. Students will be able to solve modeling problems using first-order linear and nonlinear differential equations.
   - 3.1. Students will be able to set-up and solve a suitable linear differential equation related to bacterial growth or population growth.
   - 3.2. Students will be able to set-up and solve a suitable linear differential equation related to radioactive decay.
   - 3.3. Students will be able to set-up and solve a suitable linear differential equation related to Newton’s Law of Cooling.
   - 3.4. Students will be able to set-up and solve a suitable linear differential equation related to the mixing of two fluids.
   - 3.5. Students will be able to set-up and solve a suitable linear differential equation related to Kirchoff’s law and electrical circuits.

3.6. Students will be able to set-up and solve a nonlinear logistic differential equation related to a population growth problem.
3.7. Students will be able to set-up and solve a nonlinear differential equation related to a second-order chemical reaction.
3.8. Students will be able to set-up and solve a system of linear or nonlinear differential equation related to the predator-prey model, an electrical circuit, competition models, and chemical reactions.

4. Students will be able to demonstrate knowledge of the theory and solution of higher order differential equations.
4.1. Students will be able to find a member of a family of solutions of a differential equation satisfying initial conditions.
4.2. Students will be able to find an interval around x=0 for which the given initial-value problem has a unique solution.
4.3. Students will be able to determine whether given functions are linearly dependent or independent.
4.4. Students will be able to verify that given functions form a fundamental set of solutions of a given differential equation.
4.5. Students will be able to solve a linear second-order differential equation by the method of reduction of order.
4.6. Students will be able to solve a homogeneous linear differential equation with constant coefficients by first finding the roots of the associated auxiliary equation.
4.7. Students will be able to solve a nonhomogeneous linear differential equation with constant coefficients by the method of undetermined coefficients.
4.8. Students will be able to solve a Cauchy-Euler differential equation by first finding the roots of the associated auxiliary equation.
4.9. Students will be able to solve a system of differential equations by systematic elimination.
4.10. Students will be able to solve a system of differential equations by using determinants.
4.11. Students will be able to solve a system of nonlinear differential equations by using an appropriate substitution.

5. Students will be able to solve modeling problems using higher-order differential equations.
5.1. Students will be able to set-up and solve a second-order linear differential equation for solving a spring/mass system having free undamped motion, free damped motion or driven motion.
5.2. Students will be able to set-up and solve a second-order linear differential equation for solving an LRC series circuit.
5.3. Students will be able to set-up and solve a fourth-order linear differential equation for solving a problem related to the deflection of a beam.
5.4. Students will be able to set-up and solve a second-order linear differential equation for solving a rotating string problem.
5.5. Students will be able to use an ODE solver to solve some applied problems involving nonlinear differential equations.

6. Students will be able to solve linear differential equations by the use of power series.
6.1. Students will be able to find the interval of convergence of a given power series.

6.2. Students will be able to find the first four terms of a power series representation of some common functions.
6.3. Students will be able to find the power series solutions about ordinary points of linear differential equations.
6.4. Students will be able to find the power series solutions about singular points of linear differential equations.

7. Students will be able to manipulate Laplace transforms and solve differential equations using Laplace transforms.
7.1. Students will be able to find Laplace transforms of functions using the basic definition of Laplace transforms.
7.2. Students will be able to use Laplace transforms of some common functions to find the Laplace transforms of more complicated functions.
7.3. Students will be able to find the inverse Laplace transforms of more complicated functions by using inverse Laplace transforms of some common functions.
7.4. Students will be able to use the first and second translation theorems to find the
7.5. Laplace transforms for certain functions.
7.6. Students will be able to use the inverse forms of the first and second translation theorems to find the inverse Laplace transforms for certain functions.
7.7. Students will be able to find derivatives of Laplace transforms.
7.8. Students will be able to write a given function in terms of the unit step function. 7.8. Students will be able to compute the transforms of derivatives and integrals of functions.
7.9. Students will be able to compute the transforms of periodic functions.
7.10. Students will be able to compute the transforms of a convolution and the inverse transform as a convolution.
7.11. Students will be able to solve differential equations by the use of Laplace transforms and inverse transforms.
7.12. Students will be able to solve applications by setting up the appropriate differential equations and then solving them by using transforms and inverse transforms.
7.13. Students will be able to solve systems of linear differential equations by using Laplace transforms.

8. Students will be able to solve systems of linear first-order differential equations.
8.1. Students will be able to write a given system of differential equations in matrix form.
8.2. Students will be able to write a given system without the use of matrices.
8.3. Students will be able to verify that the vector X is a solution to a given system.
8.4. Students will be able to determine if given vector solutions of a system form a fundamental set over all reals.
8.5. Students will be able to verify that the vector X sub P is a particular solution of a given system.
8.6. Students will be able to solve a system by using eigenvalues and eigenvectors.
8.7. Students will be able to solve a nonhomogeneous system by using the method of variation of parameters.