North South University
Department of Mathematics and Physics

MAT 480: Differential Equations

Course Name: **Differential Equations**
Course Code: MAT 480
Credit Hours: 3 Credits
Pre-requisite : MAT 250
Term: **Spring 2023**

Course Short Description:
Differential equation models describe a wide range of complex problems in economics, finance, engineering, biology and physical sciences. This course is intended for students who require a solid understanding and working knowledge of ordinary differential equations (ODEs) both linear and nonlinear; included are techniques and applications of ordinary differential equations in different real life problems. The course will also deal with partial differential equations (PDEs) very briefly, with some elements of numerical computation.

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Course Learning Outcomes:

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

(a) Classify and analyze solutions first order ordinary differential equations, for linear and nonlinear case. Construct mathematical models using them.
(b) Demonstrate the type of second order ordinary differential equations and use analytic methods for constructing solutions to homogeneous and nonhomogeneous second-order ODEs.
(c) Apply and analyze mathematical methods for solution of second order nonlinear ODEs.
(d) Apply Laplace transformations to find solutions of different ODEs related to real life problems.
(e) Investigate different iterative solution techniques of ODEs, for first order and second order.
(f) Recognize the PDEs, and develop skills to derive solutions of linear and nonlinear PDEs. Solve heat equation and wave equation.

Course Outline:

1. **First Order Ordinary Differential Equations:**
   Introduction to Ordinary Differential Equations (ODEs) and applications of ODEs in different fields of engineering, economics and civil background.
   Linear ODE of first order:
   Separable and Exact ODE, Linear ODE, Homogeneous Equations. Application of first order linear ODEs.
   Nonlinear ODE of first order:
   Bernoulli equation, Logistic differential equation. Modelling with first order nonlinear ODEs.
2. **Partial Differential Equations of First Order:**
   Definition of Partial Differential Equations (PDEs), Classification of PDEs, , How to generate PDEs, Solutions of PDEs, Quasilinear Equations: The Method of Characteristics, Lagrange method to solve first order linear PDEs, Charpit method to solve nonlinear first order PDEs.
3. **Linear Second-Order ODEs:**
   - **Second order ODE of constant Coefficients:**
   - **Homogeneous from:**
     Homogeneous linear ODEs of Second Order, Existence and Uniqueness of Solutions Homogeneous linear ODEs with Constant Coefficients.
   - **Non-homogeneous from:**
     General form of second –order ODEs in non-homogeneous form. Solution methods: the inverse operator method (Annihilator method), shifting exponent method, variation of parameters method; Applications of non-homogeneous ODEs of second order.
   - **Second order ODE of Variable Coefficients:**
     Cauchy Euler Equations, Existence and Uniqueness of Solutions. Wronskian, Non-homogeneous ODEs.
4. **Nonlinear Differential equations of second order: (Zill- Chapters 4.10, and 5.3)**
   - Introduction, solution of nonlinear second order ODEs: order reduction method, Taylor series solution.
5. **Laplace Transformation**
   - Laplace Transformation and its inverse, linearity and shifting, Laplace transformations of derivatives and integrals, Initial Value Problems, unit step function, delta function and t-shifting. Convolution Theorem. Application
6. **Numerical Solutions of Ordinary Differential Equations (Zill- Chapters 9.1, and 9.2)**
   - Introduction, Numerical solution of first order ODES: Euler method, Runge-Kutta method; Solution of second order ODES: Euler method. Error analysis in numerical solutions of ODEs.
7. **Classical Partial Differential Equation**
   - Introduction of classical PDEs and their characterizations. Introduction to Diffusion-type problem, Separable of variables, One-dimensional wave equations, wave equations in two dimensions.

Marks Distribution:

Attendance	**10%**
Regular Quizzes	**20%** (Minimum 05 (five) quizzes & best 03(three) quizzes will count for marks and 1/3rd syllabus must be covered for taking midterm.
Mid-term	**20%** (Duration of mid-term exam will be minimum 50 minutes).
Final Exam	**40%** (Duration of final exam will be minimum 01 hour & 30 minutes).
Assignment	**10%** (Minimum 04 assignments)
Total Marks	**100%**

Text Books: 1. A First Course in Differential Equations with Modeling and Applications, (10th Edition), Author-Dennis G. Zill.
2. Advanced Mathematical Economics, Author-Rakesh V. Vohra, publisher-Routledge, Taylor and Francis.
3. Advanced Engineering Mathematics (10th Edition)- Author: Erwin Kreyszig
4. Elementary Differential Equations and Boundary Value, Author-William E. Boyce and Richard C. DiPrima, Publisher-John Wiley & Sons.
5. Internet resources provided by course teacher.

Grading Policies: As per NSU Grading Policy

Important dates:

First midterm TBA
Course Final As per NSU Schedule

Weeks	Content	Learning Activities	Assessment tools	Learning Outcome
I-III 5 classes	**First Order Linear Ordinary Differential Equations:** Intro, Separable ODE, Exact ODE, Linear ODE	Lecture, Slides, in class discussions	Quiz 1 Midterm Assignment 1	
III- IV 2 classes	**First Order Non- Linear ODEs**: Bernoulli equation, Logistic differential equation. Modelling	Lecture, Slides, in class discussions	Midterm Assignment 1	
IV-V 3 classes	**Partial Differential Equations of First Order:** Definitions, Classifications, formulation. The Method of Characteristics, Lagrange method to solve first order linear PDEs, Charpit method	Lecture, Slides, in class discussions	Quiz 2 Midterm Assignment 1	
VI 2 classes	**Linear Second-Order ODEs: Homogeneous:** Intro, solution techniques for different types of ODEs	Lecture, Slides, in class discussions	Midterm Assignment 2	
VII 2 classes	One preparatory class for Midterm and Midterm Exam			
VIII-IX 4 classes	**Linear Second-Order ODEs: Non-Homogeneous:** Inverse operator method (Annihilator method), shifting exponent method, variation of parameters method	Lecture, Slides, in class discussions	Quiz 3 Final Exam Assignment 2	
X 2 classes	**Second order ODE of Variable Coefficients:** Cauchy Euler Equations, Existence and Uniqueness of Solutions. Wronskian, Non-homogeneous ODEs.	Lecture, Slides, in class discussions	Quiz 3 Final Exam Assignment 2	
XI 2 classes	**Nonlinear Differential equations of second order: I**ntroduction, solution of nonlinear second order ODEs: order reduction method, Taylor series solution.	Lecture, Slides, in class discussions	Final Exam Assignment 3	
XII-XIII 4 classes	**Laplace Transformation:** Laplace Transformation and its inverse, Laplace transformations of derivatives and integrals, Initial Value Problems, unit step function, s-shifting and t-shifting. Convolution Theorem. Applications	Lecture, Slides, in class discussions	Quiz 4 Final Exam Assignment 3	
XIV-XV 4 classes	**Numerical Solutions of ODEs:** Introduction, Numerical solution of first order ODES: Euler	Lecture, Slides, in class discussions	Quiz 5	

	method, Runge-Kutta method; Solution of second order ODES: Euler method. Error analysis in numerical solutions of ODEs.		Final Exam Assignment 4	
XVI-XVII 4 classes	**Classical Partial Differential Equation** Introduction of classical PDEs and their characterizations. Introduction to Diffusion-type problem, Separable of variables, One-dimensional wave equations, wave equations in two dimensions.	Lecture, Slides, in class discussions	Final Exam Assignment 4	
XVIII 2 classes	Preparatory classes for Final Exam			

Rules and Restrictions:

(a) General guidelines of NSU applied.
(b) Specific guidelines will be announced in the classes.

********** Thank You **********