

## MODULE SPECIFICATION

<b>Module Title</b>	Linear Algebra and Differential Equations
<b>Module Code</b>	MTH 232
<b>Originating Department/School</b>	Department of Mathematics
<b>Module Credits</b>	4
<b>Pre-requisites (including Year 1)</b>	Calculus III or equivalent

## Description

<b>Course Overview</b>
This course integrates foundational linear algebra with ordinary differential equations. Students develop computational proficiency, conceptual understanding, and theoretical insight into vector spaces, linear transformations, eigenvalue methods, systems of differential equations, and Laplace transform techniques. Applications from science and engineering are emphasized throughout.
<b>Method of Teaching and Learning</b>
This module will be taught using a combination of lectures, tutorials and consultation hours. Learning will also be reinforced by appropriate readings from the course text.
<b>Syllabus</b>
<p>Modules</p> <p><b>Module 1 – First-Order Differential Equations</b></p> <p>1.1 Differential Equations Everywhere</p> <p>1.2 Basic Ideas and Terminology</p> <p>1.3 The Geometry of First-Order Differential Equations</p> <p>1.4 Separable Differential Equations</p> <p>1.5 Some Simple Population Models</p> <p>1.6 First-Order Linear Differential Equations</p> <p>1.7 Modeling Problems Using First-Order Linear Differential Equations</p> <p>1.8 Change of Variables</p> <p>1.9 Exact Differential Equations</p> <p><b>Module 2 – Matrices and Systems of Linear Equations</b></p> <p>2.1 Matrices: Definitions and Notation</p> <p>2.2 Matrix Algebra</p> <p>2.3 Terminology for Systems of Linear Equations</p> <p>2.4 Row-Echelon Matrices and Elementary Row Operations</p> <p>2.5 Gaussian Elimination</p> <p>2.6 The Inverse of a Square Matrix</p>

**Module 3 – Determinants**

- 3.1 The Definition of the Determinant
- 3.2 Properties of Determinants
- 3.3 Cofactor Expansions
- 3.4 Summary of Determinants

**Module 4 – Vector Spaces**

- 4.1 Vectors in  $\mathbb{R}^n$
- 4.2 Definition of a Vector Space
- 4.3 Subspaces
- 4.4 Spanning Sets
- 4.5 Linear Dependence and Linear Independence
- 4.6 Bases and Dimension
- 4.7 Change of Basis
- 4.8 Row Space and Column Space
- 4.9 The Rank-Nullity Theorem

**Module 5 – Linear Transformations**

- 6.1 Definition of a Linear Transformation
- 6.3 The Kernel and Range of a Linear Transformation
- 6.4 Additional Properties of Linear Transformations
- 6.5 The Matrix of a Linear Transformation

**Module 6 – Eigenvalues and Eigenvectors**

- 7.1 The Eigenvalue/Eigenvector Problem
- 7.2 General Results for Eigenvalues and Eigenvectors
- 7.3 Diagonalization
- 7.4 An Introduction to the Matrix Exponential Function
- 7.5 Orthogonal Diagonalization and Quadratic Forms

**Module 7 – Linear Differential Equations of Order  $n$** 

- 8.1 General Theory for Linear Differential Equations
- 8.2 Constant Coefficient Homogeneous Linear Differential Equations
- 8.3 The Method of Undetermined Coefficients: Annihilators
- 8.4 Complex-Valued Trial Solutions
- 8.5 Oscillations of a Mechanical System
- 8.6 RLC Circuits
- 8.7 The Variation of Parameters Method

**Module 8 – Systems of Differential Equations**

- 9.1 First-Order Linear Systems
- 9.2 Vector Formulation
- 9.3 General Results for First-Order Linear Differential Systems
- 9.4 Vector Differential Equations: Nondefective Coefficient Matrix
- 9.5 Vector Differential Equations: Defective Coefficient Matrix
- 9.6 Variation-of-Parameters for Linear Systems

**Module 9 – Laplace Transforms**

- 10.1 Definition of the Laplace Transform
- 10.2 The Existence of the Laplace Transform and the Inverse Transform

10.4 The Transform of Derivatives and Solution of Initial Value Problems
10.5 The First Shifting Theorem
10.6 The Unit Step Function
10.7 The Second Shifting Theorem
10.8 Impulsive Driving Terms: The Dirac Delta Function

## Assessment

Assessment Type	% of Final Mark
Midterm Exam 1	25%
Midterm Exam 2	25%
Final Exam	30%
Homework	10%
Course Participation	10%

<i>Range</i>	<i>Letter Grade</i>
90% - 100%	A
80% - 89%	B
70% - 79%	C
60% - 69%	D
< 60%	U

## Textbooks

### *Mandatory Textbooks*

Title	Author	ISBN/Publisher
Differential Equations and Linear Algebra, 4th edition	Stephen W. Goode and Scott A. Annin	

### *Optional Textbooks*

Title	Author	ISBN/Publisher
-------	--------	----------------

### *Reference Textbooks*

Title	Author	ISBN/Publisher
-------	--------	----------------