National University of Technology (NUTECH)

Course Plan

COURSE CODE:	MATH3301
COURSE NAME:	Linear Algebra and Ordinary Differential Equations (LA & ODE)
CREDIT HOURS:	4 (Theory) + 0 (Practical)
CONTACT HOURS:	64 (Theory)
NUTECH UNITS	4-0-8-12
PREREQUISITES:	MATH1102 Calculus II
MODE OF TEACHING:	Lectures and Problem-Solving Activities
DISCIPLINE:	BET (Mechanical)

SUBJECT DESCRIPTION:

This is a typical course to lead students through a traditional sequence of topics related to linear algebra (LA) and ordinary differential equations (ODE). At every opportunity a modeling activity will be used to introduce and support the study of differential equations.

In LA, the following concepts will be covered.

- Introduction to systems of linear equations;
- Matrices and matrix operations; Matrix arithmetic;
- Gaussian elimination; Determinants; Inverses; Factorization
- Eigenvalues and eigenvectors;
- Concepts of vector spaces; Linear independence and dependence of vectors.

In ODE, the following concepts will be covered.

- First order ODEs: Separable, Homogenous, Exact, and Linear ODE, and ODE reducible to aforementioned forms. Some non-linear first order ODE; Applications;
- Higher order ODES: Homogenous and non-homogeneous linear ODE with constant coefficients; Equations with variable coefficients (Cauchy-Euler equations; Methods of variations of parameters; Power series solutions); Applications;
- Laplace transform and inverse Laplace transform: Dirac delta and gamma functions; Unit step function; Shift theorems; Application to solve linear initial and boundary value problems.

SUBJECT OBJECTIVES:

1. To provide students a deep understanding of the basic concepts of linear algebra and ODE and hand on practice of necessary mathematical tool-kit for solving ODE.

2. To enable students with ample knowledge and problem-solving skills for modeling simple engineering and real-life scenarios using differential equations and rendering their reliable solutions.

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SUBJECT LEARNING OUTCOMES:

At the end of the course, students would be able to:

	SLO	Learning Domain	Taxonomy Level	PLO
1.	***Apply*** the concepts of elementary linear algebra including matrix operations to solve system of equations.	Cognitive	3	1
2.	***Solve*** first order and higher order ordinary differential equations.			
3.	***Model*** simple engineering and real-life scenarios using ordinary differential equations.			
4.	***Calculate*** Laplace and inverse Laplace transforms of smooth functions with applications to ODE.			

TEXT AND MATERIAL:

Textbook (s)

1. D. C. Lay, Linear Algebra and its Applications (4th edition), Addison-Wesley, 2012.
2. D. G. Zill, W. S. Wright and M. R. Cullen, Differential Equations with Boundary Value Problems (8th edition), Richard Stratton Publishers, 2013.

References Material:

3. T. S. Shores, Applied Linear Algebra and Matrix Analysis, Undergraduate Texts in Mathematics, Springer Verlag, 2007.
4. G. Strang, Introduction to Linear Algebra (5th edition), Wellesley-Cambridge Press, 2016.
5. R. O'Malley, Differential Equations and Linear Algebra, Wellesley-Cambridge Press, 2014.
6. E. Kreyszig, Advanced Engineering Mathematics (10th edition), John-Wiley & Sons.

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☐
2	Problem Analysis:	☐	8	Ethics:	☐
3	Design/Development of Solutions:	☐	9	Individual and Team Work:	☐
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☐	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

RELEVANCE OF COURSE TO REAL LIFE (PRACTICAL APPLICATIONS):

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Differential equations have a remarkable ability to predict the world around us. They are used in a wide variety of disciplines, from biology, economics, physics, chemistry, and engineering. They can describe exponential growth and decay, the population growth of species or the change in investment return over time.

In all aspects of engineering, when confronted with a problem, one usually defines the problem with a model using mathematical equations describing the relationships of different aspects of the problem, usually through differential equations. Basic things that occur all the time in engineering are rates of change with respect to time, or space variables such as heat, wave, gas, electromagnetic fields, conductivity, vibrations in solids like bridges and buildings, and many others and are therefore, modeled with differential equations.

Differential equations are used almost everywhere in mechanical engineering. For example, fluid mechanics, almost all of it, is about differential equations. Mass transfer, like fluid mechanics, can only be understood completely through differential equations. Newton's second law of motion, solving it is what dynamics is all about, is a second order differential equation. Statics requires it for beam deflections. Similarly, the processes such as, welding, solidification, combustion, diffusion, and turbulence cannot be explained without understanding of differential equations.

ASSESSMENT SYSTEM:

There will be 6 Homework Assignments, 8 Quizzes, 1 Midterm and 1 Final Exam. Date of submission of assignments will be reflected. Late submission will have a penalty (deduction of 20% marks for each day of late submission, zero marks for submission delayed more than 5 days).

To encourage reading (reading assignments are reflected in course schedule) and discourage copying of homework assignments, all quizzes will be 50% from reading assignments and 50% from problem sets in assignments. Relative grading system will be followed to award grades. Weightages are as under:

Theoretical/Instruction	**No**	**Percentage**
Assignments	6	10%
Quizzes	8	10%
Midterm Exam	1	30%
End Semester Exam	1	50%
Total		**100%**

Note: Assignments and solution keys to Quizzes / Exams / Assignments will be disseminated at the weblink: https://abdulwahabmalik.weebly.com/teaching.html. Students are advised to visit the page frequently for updates.

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CONDUCT IN THE CLASS:

- Discussion is encouraged in class but cross talking is not allowed.
- Everyone should be seated in the class 2 minutes before the start of the class.
- Leave / Absent will be considered as **"ABSENT"** in class, for which no retake of Assignments, Quiz etc. will be considered.
- Copying / late submission of assignments will result in deduction of marks.
- Phones should be on silent mode.

INSTRUCTOR:

Name: Dr. Abdul Wahab
Office: NUSASH, Academic Block, 5th floor
Email: wahab@nutech.edu.pk

Class Hours: Check weekly training programs for class timings.
Office Hours: Wed: 12:00 – 13:00 (and by appointments).

INSTRUCTOR'S EXPERIENCE

Dr. Abdul Wahab is a Doctor of École Polytechnique, Paris in Applied Mathematics and has research interests in direct and inverse scattering of waves in complex media. He seeks solutions of inverse problems related to Biomedical Imaging, Non-Destructive Testing, and Exploration Geophysics. He has vast experience of teaching a number of courses including Linear Algebra, Ordinary Differential Equations, Partial Differential Equations, Topology, Numerical Analysis, Calculus and Analytic Geometry, Discrete Mathematics, and Mathematical Methods for Physics.

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DETAILED CONTENTS AND THEIR CONTRIBUTION TO PLOs:

Week	Topic Covered	Reading Assignment/ Home Work	SLO No.	PLO No.	Assessment Methodology	Learning Domain	Level of Learning 1-6
1	Introduction to Linear Algebra; System of Linear Equations; Matrix Notation; Elementary Matrices and Row Operations; Row reduction and Echelon Forms	Ref 1, Sec. 1.1 to 1.2	1	1	Assignment, Quizzes, OHT, Formative Assessments	Cognitive Domain	1-3
2	Vector Equations; The Matrix Equation AX=B; Solution sets of Linear Systems; Linear Independence; Applications of Linear Systems	Ref 1, Sec. 1.3 to 1.6 Quiz 1	1				
3	Matrix Operations; The Inverse of a Matrix, Characterizations of Invertible Matrices; LU Factorization; Subspaces of R^N; Rank and Dimensionality	Ref 1, Sect. 2.1 to 2.5; Sec. 2.8 to 2.9 Assignment 1	1				
4	Determinants; Cramer's Rule; Concept of Vector Spaces; Null space; Column Space; Kernel and Range Spaces of a Linear Transformation; Eigen Values and Eigen Vectors;	Ref 1, Sec. 3.1 to 3.3; Sec. 4.1 to 4.2; Sec. 5.1 to 5.2 Quiz 2	1				
5	Introduction to Differential Equations; Definitions and Terminologies; Initial Value Problems; Differential Equations as Mathematical Models;	Ref 2: Chapter 1 Assignment 2	2,3				

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6	Separable Equations; Linear Equations; Reducible to Separable and Linear Equations	Ref 2, Sec. 2.1 to 2.3 Quiz 3	2,3				
7	Exact Equations; Homogeneous Equations; Integrating Factors; Reducible to Exact and Homogeneous Equations	Ref 2, Sec. 2.4 to 2.5 Assignment 3	2,3				
8	Modeling of real life and engineering with First-Order ODE's.	Ref 2, Chapter 3: Additional and Advance Exercises Quiz 4	2,3				
	Midterm Exam						
9	Higher-Order ODE; Preliminaries; Superposition Principle; Reduction of Order; Homogeneous and Non-Homogeneous Linear Constant Coefficient ODE; UC Method; Annihilator Approach	Ref 2, Sec 4.1 to 4.5 Assignment 4	2,3				
10	Variation of Parameters; Cauchy-Euler Equation; Boundary-Value Problems; Systems of Linear ODES by Elimination;	Ref 2, Sec.4.6, 4.7, 4.9 Quiz 5	2,3				
11	Some Non-Linear ODES; Modeling with Higher-Order ODE's	Ref 2, Sec. 4.10; and Chapter 5: Assignment 5	2,3				
12	Series Solutions of Linear Equations	Ref 2, Sec 6.1 to 6.3 (Sec. 6.4 Optional)	2,3				

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		Quiz 6					
13	Laplace Transform: Preliminaries; Transforms of Different Functions; Inverse Transforms; Transforms of Derivatives; Translation Properties;	Ref 2, Sec. 7.1 to 7.3 Assignment 6	4				
14	Derivatives of Transforms; Transforms of Integrals; Dirac Delta Function; Solution of IVP and BVP using Laplace Transform	Ref 2, Sec. 7.4 to 7.6 Quiz 7	4				
15	Numerical Solutions of ODES: Euler Methods and Runge-Kutta Methods	Ref 2, Sec. 9.1 to 9.2 Quiz 8	4				
16	Review		4				
Final Exam					**End Semester Exam**		

Prepared By: **Dr. Abdul Wahab** _____

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Vetted By: **Prof. Umair Manzoor** _____

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