BMS INSTITUTE OF TECHNOLOGY & MANAGEMENT

(An Autonomous Institute affiliated to Visvesvaraya Technological University, Belagavi)

Avalahalli, Doddaballapur Main Road, Bengaluru – 560119

DEPARTMENT OF MATHEMATICS

Choice Based Credit System (CBCS)

SEMESTER-II

ORDINARY DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS

(Common to CSE, AI&ML and CSBS Branches)

(Effective from the Academic year 2024-25)

Course Code:	**BMATCS21**	CIE Marks	50
Course Type (Theory/Practical/Integrated)	Integrated	SEE Marks	50
		Total Marks	100
Credits distribution (L:T:P:S)	3:0.5:0.5:0	Credits	04
Total Hours of Pedagogy	40 hours Theory + 10 hours Lab	Exam Hours	03

Course Objectives: The goal of the course Ordinary differential equations and numerical methods (24MATCS21) is to

- **Have an insight** into ordinary differential equations to solve problems arising in computer science engineering.
- **Develop** mathematical skills to solve algebraic, transcendental and ordinary differential equation problems numerically.
- **Familiarize** with modern mathematical tools like MATLAB.

Teaching-Learning Process

Pedagogy(General Instructions):

These are sample strategies which teachers can use to accelerate the attainment of various Courseoutcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop student's theoretical and appliedmathematical skills.
2. State the need for Mathematics with engineering studies and provide real-life examples.
3. Support and guide the students for self–study.
4. You will also be responsible for assigning homework, grading assignments and quizzes, anddocumenting students' progress.
5. Encourage the students for group learning to improve their creative and analytical skills.
6. Show short video lectures in the following ways as:
   - an introduction to new topics (pre-lecture activity).
   - a revision of topics (post-lecture activity).
   - additional examples (post-lecture activity).
   - an additional material of challenging topics (pre-and post-lecture activity).
   - a model solution of some exercises (post-lecture activity).

Module – 1 Ordinary Differential Equations (ODEs) of first order (8 hours)
Introduction, Linear and Bernoulli's differential equations. Exact differential equations and equations reducible to exact differential equations- Integrating factors on $\frac{1}{N}\left(\frac{\partial M}{\partial y}-\frac{\partial N}{\partial x}\right)$ and $\frac{1}{M}\left(\frac{\partial N}{\partial x}-\frac{\partial M}{\partial y}\right)$, Orthogonal trajectories. Nonlinear differential equations: Introduction to general and singular solutions, Solvable for p only, Clairaut's equations, reducible to Clairaut's equations, problems. **Applications:** Rate of Growth or Decay, Newton's law of cooling. **(RBT Levels: L1, L2 and L3)**
Module – 2 Ordinary Differential Equations (ODEs) of higher order (8 hours)
Introduction, solution of homogeneous linear ODE, solution of non-homogeneous linear ODE of higher order with constant coefficients $f(D)y = X$ using inverse differential operator $X = ke^{ax}$, $X = ksin(ax+b)$ *or* $kcos(ax+b)$ and X is a polynomial, Method of variation of parameters, problems. solution of linear ODE with variable coefficients-Cauchy's and Legendre's differential equations, problems. **Applications:** Pricing policy for production of goods, Population growth of two countries.
Module - 3 Numerical Methods -1 (8 hours)
Introduction, Finite differences, Interpolation- Newton's forward and backward interpolation formulae, Newton'sdivided difference formula, Lagrange's interpolation formula and Lagrange's inverse interpolation formula (formulae without proofs), problems. Numerical integration: Trapezoidal rule, Simpson's $(1/3)^{rd}$ rule & Simpson's $(3/8)^{th}$ rule (without proofs), problems. **Applications:** Estimating distance, velocity, area and volume. **(RBT Levels: L1, L2 and L3)**
Module -4 Numerical Methods -2 (8 hours)
Introduction, Numerical solution of ordinary differential equations of first order and first degree - Taylor's series method, Modified Euler's method, Runge-Kutta method of fourth order, Milne's predictor-corrector and Adams-Bashforth formulae (without proofs), problems. **Applications:** Error Analysis. **(RBT Levels: L1, L2 and L3)**
Module - 5 Numerical Methods -3 (8 hours)
Introduction, Numerical solution of simultaneous first order ODE- Runge-Kutta method of fourth order, Numerical solution of second order ODE - Runge-Kutta method of fourth order and Milne's predictor-corrector formula (only formulae), problems. Numerical solution of algebraic and transcendental equations - Regula-Falsi and Newton-Raphson methods (only formulae), problems. **Applications:** Chemical reaction. **(RBT Levels: L1, L2 and L3)**

List of Laboratory experiments (1 hour/week): 10 lab sessions + 1 Lab Assessment

1	Solution of first order differential equation.
2	Solution of differential equations with initial conditions.
3	Solution of homogeneous ordinary differential equations of higher order.
4	Solution of non-homogeneous ordinary differential equations of higher order.
5	Newton's forward and backward difference interpolation formula.
6	Numerical integration using Trapezoidal, Simpson's (1/3)rd and (3/8)th rules.
7	Solution of ODE of first order and first degree by Modified Euler's method.
8	Solution of ODE of first order and first degree by Runge-Kutta 4th order method.
9	Solution of algebraic and transcendental equations by Regula-Falsi method.
10	Solution of algebraic and transcendental equations by Newton-Raphson method.

Suggested software: MATLAB

Suggested Learning Resources:

Text Books:

1. **B. S. Grewal:** "Higher Engineering Mathematics", Khanna Publishers, 44th Ed., 2021.
2. **E. Kreyszig:** "Advanced Engineering Mathematics", John Wiley & Sons, 10thEd., 2018.

Reference Books:

1. **Srimanta Pal & Subodh C. Bhunia:** "Engineering Mathematics" Oxford University Press, 3rd Ed., 2016.
2. **N.P Bali and Manish Goyal:** "A Textbook of Engineering Mathematics" Laxmi Publications, 10th Ed., 2022.
3. **C. Ray Wylie, Louis C. Barrett**: "Advanced Engineering Mathematics" McGraw – Hill Book Co., New York, 6th Ed., 2017.
4. **H. K. Dass and Er. Rajnish Verma:** "Higher Engineering Mathematics" S. Chand Publication, 3rd Ed., 2014.
5. **Gupta C.B, Sing S.R and Mukesh Kumar:** "Engineering Mathematics for Semester I and II", McGraw Hill Education (India) Pvt. Ltd, 2015.

Web links and Video Lectures (e-Resources):

- http://nptel.ac.in/courses.php?disciplineID=111
- http://www.class-central.com/subject/math(MOOCs)
- http://academicearth.org/
- VTU e-Shikshana Program
- VTU EDUSAT Program
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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes
- Assignments
- Seminar

Course outcomes (COs):

At the end of the Course, the student will be able to:

CO1	Solve higher order ordinary differential equations analytically.
CO2	Identify appropriate numerical methods to interpolate/extrapolate and integrate the given set of data points.
CO3	Solve ODE and algebraic/transcendental equations numerically.
CO4	Familiarize with modern mathematical tools using MATLAB.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**1**										
CO2	**3**	**1**										
CO3	**3**	**1**										
CO4					**3**							

Level 3: Highly mapped Level 2: Moderately mapped Level 1: Low mapped