Multivariable Calculus and Numerical Methods		Semester	2
Course Code	**1BMATM201**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40Hours Theory + 20-24Hours Tutorials	Total Marks	100
Credits	4 Credits	Exam Hours	3 Hours
Examination type (SEE)	**Theory**		

Course outcome (Course Skill Set)

CO1: Apply the concepts of integral calculus, higher order differential equations, and vector calculus to model and solve problems in engineering applications such as area, volume, heat conduction, and field analysis.

CO2: Apply appropriate numerical methods to find approximate solutions of algebraic, transcendental, and ordinary differential equations and to perform interpolation and numerical integration in engineering contexts.

CO3: Demonstrate the applications of mechanical engineering and allied engineering science using modern ICT tools.

Module-1: Integral Calculus (8 Hours Theory + 4 Hours Tutorial)

Multiple Integrals: Definition, Evaluation of double and triple integrals, evaluation of double integrals by change of order of integration, changing into polar coordinates. Applications to find Area and Volume by double integral.

Beta and Gamma functions: Definitions, properties, relation between Beta and Gamma functions.

Textbook 1: Chapter:7.1-7.16

Module-2: Ordinary Differential Equations of Higher Order(8 Hours Theory + 4 Hours Tutorial)

Higher-order ordinary differential equations with constant coefficients, homogeneous and non-homogeneous equations-e^{ax}, sin(ax+b), cos(ax+b), x^n only, Method of variation of parameters, Cauchy's and Legendre's homogeneous differential equations. Applications: mass spring model.

Textbook 1: Chapter 17.8-17.12, Chapter 13.4-13.9(1,2), Chapter 14:14.2,
Textbook 2: Chapter 9: 9.13

Module-3: Vector Calculus (8 Hours Theory + 4 Hours Tutorial)

Scalar and vector fields. Gradient, directional derivative, divergence and curl-physical interpretation, solenoidal vector fields, irrotational vector fields and scalar potential.

Vector Integration: Line integrals, work done by a force and flux. Statement of Green's theorem and Stoke's theorem and problems without verifications.

Textbook 1: Chapter 8 :8.4,8.5,8.6,8.7(1,2),8.9,8.18(1),8.11,8.13,8.14,8.17

Module-4: Numerical Methods- 1 (8 Hours Theory + 4 Hours Tutorial)

Solution of algebraic and transcendental equations: Regula-Falsi and Newton-Raphson methods.

Interpolation: Finite differences, Interpolation using Newton's forward and backward difference formulae, Newton's divided difference formula and Lagrange's interpolation formula.

Numerical integration: Trapezoidal, Simpson's1/3rd and 3/8thrules.

Textbook1:Chapter28: Chapter29:29.1-29.12,Chapter 30:30.2-,30.8

Module-5: Numerical Methods– 2 (8 Hours Theory + 4 Hours Tutorial)

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 formula and Adams-Bashforth predictor-corrector method.

Textbook 1: Chapter 32 :32.3- 32.10

Suggested Learning Resources: (Textbook/Reference Book):

Textbooks:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers,44nd Ed., 2021.
2. B.V.Ramana, HigherEngineeringMathematics,McGraw-HillEducation,11thEd., 2017
3. E.Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons,10th Ed.,2018.
4. M.K. Jain, S.R.K. Iyengar and R.K. Jain:Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 8thEd., 2022.

Reference books:

1. Srimanta Pal & Subodh C.Bhunia, Engineering Mathematics, Oxford University Press, 3rd Ed., 2016.
2. N. P.Baliand ManishGoyal, A Text book of Engineering Mathematics, Laxmi Publications,10thEd.,2022.
3. H.K.Dassand Er.RajnishVerma, Higher Engineering Mathematics, S.Chand Publication, 3rd Ed., 2014.
4. Ray Wylie, Louis C.Barrett, Advanced Engineering Mathematics, McGrawHill Book Co., New York, 6th Ed., 2017.
5. Steven V. Chapra and Raymond P. Canale, Applied Numerical Methods with Matlab for Engineers and Scientists, Mc Graw-Hill,3rdEd., 2011.

7. Richard L. Burden, Douglas J. Faires and A. M. Burden, Numerical Analysis, 10th Ed.,2010, Cengage Publishers.
8. S.S. Sastry,"Introductory Methods of Numerical Analysis",PHI Learning Private Limited, 5thEd.,2012.

Web links and Video Lectures (e-Resources):

- http://academicearth.org/
- VTUe-ShikshanaProgram
- VTUEDUSATProgram
- https://nptel.ac.in/courses/111105160
- https://nptel.ac.in/courses/127106019
- https://ocw.mit.edu/courses/18-335j-introduction-to-numerical-methods-spring-2019/
- https://ocw.mit.edu/courses/18-330-introduction-to-numerical-analysis-spring-2012/pages/syllabus/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop students' theoretical and applied mathematical 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, and documenting students' progress.
5. Encourage the students to group learning to improve their creative and analytical skills.
6. Show short-related video lectures in the following ways:
   - As an introduction to new topics (pre-lecture activity).
   - As a revision of topics (post-lecture activity).
   - As additional examples (post-lecture activity).
   - As an additional material of challenging topics (pre-and post-lecture activity).
   - As a model solution of some exercises (post-lecture activity).

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.
The CIE Theory component consists of average of TWO IA tests for 25 marks and Continuous Comprehensive Assessments (CCA) for 25 marks.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE is at least 40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA):

CCA will be conducted with a total of 25 marks. It is recommended to include a maximum of two learning activities aimed at enhancing the holistic development of students. These activities should align with course objectives and promote higher-order thinking and application-based learning.

Learning Activity-1: Tutorial: Practicing problems (Lab Activities/Surprise Test/ Seminar for 15 Marks) (Gate-based Aptitude Test)Execute the following lab exercises with the aid of any modern technological tool (Matlab/Mathematica/Scilab/Python/Maxima, etc).

Learning Activity-2: The students have to present applications of mathematics related to syllabus as a group maximum of five members.

List of Lab Activities:

1) Evaluate double and triple integration and compute area and volume,
2) Solve higher order differential equations,
3) Finding gradient, divergence and curl,
4) Evaluate line integrals,
5) Regula Falsi and Newton Raphson method,
6) Interpolation,
7) Numerical integration,
8) Modified Euler's method,
9) Fourth order Runge -Kutta method,
10) Milne's method.

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Activity-1	Superior (13-15)	Good (10-12)	Fair (7-9)	Needs Improvement (4-6)	Unacceptable (0-3)
Performance Indicator- 1 (CO-1/PO - 1, PO-12, Mapping)	Demonstrates complete understanding of the topic	Shows good understanding with minor errors	some key points are missing	Shows little understanding	Very poor performance
Performance Indicator-2 (CO-2/PO-1/ PO-12, Mapping)	creatively to solve problems	Participates regularly but may need occasional prompting	Demonstrates partial understanding	major misconceptions present	Inadequate performance
Activity-2	9-10	7-8	5-6	3-4	1-2
Performance Indicator-3 (CO-3/PO-5 PO-12, Mapping)	perform tasks independently	Applies knowledge correctly	limited creativity.	Unable to apply knowledge appropriately.	Identical performance

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play