NUMERICAL METHODS		Semester	2
Course Code	**1BMATS201**	CIE Marks	50
Teaching Hours/Week (L: T: P: S)	3:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40Hours Theory + 20Hours Tutorial	Total Marks	100
Credits	4	Exam Hours	3 hrs
Examination type (SEE)	**Theory**		

Course outcome (Course Skill Set)

CO1: Apply numerical methods to solve transcendental equations, perform interpolation, numerical integration, and solve ordinary differential equations.

CO2: Solve first and higher-order differential equations using analytical methods and apply them to mathematical models.

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

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

Errors and their computation: Round off error, Truncation error, Absolute error, Relative error and Percentage error.

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

Textbook-1: Chapter-1: section 1.3, Chapter-2: sections 2.1-2.3.

Module-2: Numerical solutions for system of linear equations (8Hours Theory + 4Hours Tutorial)

Norms: Vector norms and Matrix norms-L_1, L_2 and L_∞, Ill conditioned linear system, condition number.

Solution of system of linear equations: Gauss Seidel method and LU-decomposition method.

Eigenvalues and Eigen vectors: Rayleigh power method, Jacobi's method

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

Finite differences, interpolation using Newton Gregary forward and Newton Gregary backward difference formulae, Newton's divided difference. Lagrange interpolation formulae, piecewise interpolation-linear and quadratic.

Textbook-1: Chapter-4: sections 4.1-4.4, 4.6

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

Linear and Bernoulli`s differential equations. Exact and reducible to exact differential equations with integrating factors on $\frac{1}{N}\left(\frac{\partial M}{\partial y}-\frac{\partial N}{\partial x}\right)$ and $\frac{-1}{M}\left(\frac{\partial M}{\partial y}-\frac{\partial N}{\partial x}\right)$. Homogeneous and non-homogeneous Differential equations of higher order with constant coefficients. Inverse differential operators - e^{ax}, sin(ax+b), cos(ax+b) and x^n.

Textbook-3: Chapter-11: Sections 11.9-11.12 Chapter-13: Sections 13.1-13.7

Module-5: Numerical Integration and Numerical Solution of Differential Equations (8Hours Theory + 4Hours Tutorial)

Numerical integration: Trapezoidal, Simpson's 1/3rd, Simpson's 3/8th rule and Weddle's rule. 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 and Milne's predictor-corrector method.

Textbook-1: Chapter-5: Sections 5.6, 5.7. Chapter-6: Sections 6.3, 6.4, 6.7

Textbook-3: Chapter-30: Sections 30.4-30.10, Chapter-32: Sections 32.3-32.9,

Suggested Learning Resources: (Textbook/Reference Book):

Textbooks:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 8thEd., 2022.
2. David C Lay, Linear Algebra and its Applications, Pearson Publishers, 5th Ed., 2023.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44thEd., 2021.

Reference books:

1. V. Ramana, Higher Engineering Mathematics, McGraw-Hill Education, 11th Ed., 2017
2. N. P. Bali and Manish Goyal, A Textbook of Engineering Mathematics, Laxmi Publications, 10th Ed., 2022.
3. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI Learning Private Limited, 5th Ed. 2012.
4. Steven V. Chapra and Raymond P. Canale, Applied Numerical Methods with Matlab for Engineers and Scientists, McGraw-Hill, 3rd Ed., 2011.
5. Richard L. Burden, Douglas J. Faires, A. M. Burden, Numerical Analysis, 10th Edition.,2010, Cengage Publishers.

Web links and Video Lectures (e-Resources):

- http://academicearth.org/
- VTU e-Shikshana Program
- VTU EDUSAT Program
- 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) Execute the following lab exercises with the aid of any modern technological tool (Matlab/ Mathematica/ Scilab/ Python/ Maxima, etc).

Learning Activity-2: Assignments (Marks-10).

List of Lab Activities:

1) Errors and approximation,
2) Root finding methods,
3) Norms, Condition number,
4) Gauss Seidel method and Rayleigh power's method,
5) Forward and Backward interpolation,
6) Lagrange's interpolation,
7) Solving differential equations of first and higher order,
8) Numerical integration,
9) Taylor's method, Modified Euler's method,
10) Runge-Kutta method of fourth order.

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