GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Rubber Technology

Subject Code : BE03026041

Subject Name: Numerical Methods in Rubber Technology

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	BSC

Prerequisite:	None
Rationale:	In the field of rubber technology, engineers and researchers often face complex mathematical problems that arise in the analysis and design of materials, processes, and systems. Many of these problems involve non-linear behaviours, viscoelastic properties, heat transfer, and dynamic responses, which cannot be solved analytically. Numerical methods provide robust and efficient techniques to address these challenges, making them an essential tool for modern rubber engineering and research. This course aims to bridge the gap between theoretical principles and practical applications by teaching students to use numerical methods for solving engineering problems specific to rubber technology. This course is designed to meet the growing demand for engineers who can apply computational techniques to solve complex problems in rubber technology.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Understand numerical methods and their importance
02	Apply root-finding techniques and interpolation for analyzing material properties
03	Solve ODEs and BVPs for dynamic and thermal behavior
04	Implement numerical methods in Python for rubber technology applications

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	15	0	60	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Introduction to Numerical Methods in Rubber Engineering** Overview of Numerical Methods and their Applications in Rubber Technology, Types of Errors in Numerical Methods: Truncation Errors, Round-off Errors, Absolute Errors, Relative Errors, Importance of Numerical Accuracy in Material Modeling and Process Simulations: Material Modeling, Process Simulations, Component Design, Lifecycle Predictions, Cost and Resource Optimization, Environmental and Sustainability Aspects.	**5**	**12**
2	**Roots of Equations:** Introduction, difference between exact solutions and roots by numerical approaches, Basic properties of equations, Transformation of equations, Iterative Methods: Bracketing Methods and Open-end Methods, Comparison of Bracketing & Open-end Methods, Graphical Solution of Equations, Roots of Polynomials Equations, Multiple Roots, Complex Roots. (examples based on applications in rubber technology)	**7**	**15**
3	**Interpolation and Approximation** Interpolation with unequal intervals, Lagrange interpolation, Newton's divided difference interpolation, Cubic Splines, Interpolation with equal intervals, Newton's forward and backward difference formulae, Linear curve fitting, Least square method. (examples based on applications in rubber technology)	**7**	**15**
4	**Ordinary Differential Equations: Initial Value Problems** Introduction, Explicit and Implicit Methods, Predictor Corrector and Runge-Kutta methods, Stability of algorithms, Stiffness analysis, Gear's technique for stiff equations (. (examples based on applications in rubber technology**)**	**8**	**20**
5	**Boundary value problems (BVP) in ordinary and partial differential equations (PDE)** Introduction to BVP and PDE, Finite difference methods for solving two-point linear boundary value problems. Finite difference techniques for the solution of two dimensional Laplace's and Poisson's equations on rectangular domain – One dimensional heat-flow equation by explicit and implicit (Crank Nicholson) methods – One dimensional wave equation by explicit method, Numerical Analysis of the one-Dimensional Polymer Flow (examples based on applications in rubber technology)	**10**	**22**
6	**Applications of Numerical Methods using Python** Introduction to Python, Basic Operations and Control, Plotting and Visualization, Data Analysis, examples based on applications in rubber technology for solution of Ordinary and Partial Differential Equations in python	**8**	**16**

	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	10	20	15	10	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Numerical Methods for Engineers By Santosh K Gupta
2. Numerical Methods In engineering And science B. S. Grewal
3. Numerical Methods for Engineers by Steven C. Chapra & Raymond P. Canale

(b) Open source software and website:

- https://www.coursera.org/learn/differential-equations-engineers
- https://www.coursera.org/learn/numerical-methods-engineers
- https://www.coursera.org/learn/applied-calculus-with-python
- https://www.coursera.org/learn/python
- https://www.coursera.org/learn/industrial-optimization-models--linear-programming

Suggested Course Practical List: If any

Tutorial based on above topics.

List of Laboratory/Learning Resources Required:

Suggested Project List:

1. Error Analysis in Rubber Material Modeling
2. Root-Finding for Rubber Compound Formulation
3. Interpolation Techniques in Rubber Testing Data

4. Numerical Simulation of Rubber Aging
5. Heat Flow Analysis in Rubber Components
6. Python-Based Numerical Modeling of Polymer Flow
7. Boundary Value Problem Analysis in Rubber Sealing Applications
8. Numerical Modeling of Polymer Fluid Dynamics
9. Machine Learning and Numerical Methods Integration
10. Finite Difference Analysis of Rubber Molding Processes

- **List of suggested activities for Problem Based Learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Online Course	Minimum duration of the course should be 20 h.	Based on assignment submitted and certificate produced.
2.	Self-Learning Through Assignment Creation related to subject	Completion of five independent tasks, each designed for a 3-hour engagement. Total = 15h	Based on assignment submitted.
3.	Case Study Analysis related to subject	Duration of data collection -6 h Report preparation – 4h Total- 10 h	Based on Problem identification, depth of analysis, technical insight, application relevance
4.	Mini Projects related to subject	Duration – 20 h	Based on Project Report Submitted.
5.	Technical Article/Video Reviews related to subject	Duration of Review -6h Report preparation -4h Total-10h	Relevance of content, clarity of summary, insights drawn, conceptual understanding
6.	Literature review and Concept Mapping	Duration -6h Report preparation- 4h Total-10 h	Based on selection of a topic, creation of concept map, Accuracy, structure, completeness, clarity and coverage of key concepts
7.	Online Simulations and	Duration -12 hours	Based on report submitted. Report

	Virtual Labs Using platforms like MATLAB Online, Virtual Labs India, Python, TinkerCAD for hands-on virtual practice		should contain coding, programming, experimental procedures and results interpretation.
8.	Peer Teaching Video	2 video preparation -10 h	Create a 5–10-minute video explaining a rubber technology concept for peers, incorporating visuals.
9.	Glossary Compilation	Duration -5h	Based on report submitted. Report should contain Accuracy, completeness, formatting, and use of illustrations/examples
10.	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
11.	Visual presentation of technical content through posters, charts, or PowerPoint slides	Duration = 10 h	Based on quality of poster/chart preparation, creativity, accuracy and effectiveness of presentation skills.
12.	Software tool learning and Practice	Duration = 20 h	Based on report submitted. Report should contain the details of learning tools and its application.

Note:

- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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