GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester -II

Course Title: **Engineering Mathematics**
(Course Code: C4320002)

Diploma programmes in which this course is offered	Semester in which offered
Biomedical Engineering, Computer Engineering, Electrical Engineering, Electronics & Communication Engineering, Environment Engineering, Information Technology, Instrumentation & Control Engineering, Power Electronics Engineering	Second

1. RATIONALE

This course is an extension of the course based on Mathematics of first semester namely Engineering Mathematics. The course is designed to inculcate its applications in relevant branch of engineering and technology using the techniques of Differentiation, Integration, Differential equations, Matrix theory and Complex numbers. Calculus is a branch of Mathematics that calculates how matter, particles and heavenly bodies actually move. With calculus, we can find how the changing conditions of a system affect us, we can control a system. Derivatives are useful to find maxima and minima of the function, velocity and acceleration and also useful for many engineering optimization problems. Definite integrals are a powerful tool to help us realize and model the world around us. Differential equations are widely applied to model natural phenomena, engineering systems and many other situations. Matrix analysis is a valuable tool used in nearly all the engineering sciences. Complex numbers, is one of the most elegant and interesting topics in mathematics. Complex numbers, their algebra and geometry has always been an important tool to crack thousands of the problems based on Pure and Applied Mathematics. In fact, some properties are easier in complex than real variables. DeMoivre's Theorem is one of the most important and useful theorems which connects complex numbers and trigonometry and also helpful for obtaining relationships between trigonometric functions of multiple angles. This course further develops the skills and understanding of mathematical concepts which underpin the investigative tools used for modeling and analysis in a wide range of applications in engineering.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Solve broad-based technology problems using the principles of engineering mathematics.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Demonstrate the ability to Crack engineering related problems based on Matrices.
b) Demonstrate the ability to solve engineering related problems based on applications of differentiation.
c) Demonstrate the ability to solve engineering related problems based on applications of integration.
d) Develop the ability to apply differential equations to significant applied problems.
e) Represent complex numbers algebraically and geometrically for solving engineering related problems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	1	-	4	30*	70	-	-	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL/TUTORIALS EXERCISES (During Tutorial Hours)

The following practical outcomes (PrOs)/Tutorials are the sub-components of the COs. *Some of the **PrOs/Tutorials** marked **'*'** (in approx. Hrs column) are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)/Tutorials	Unit No.	Approx. Hrs. required
1	Solve simple problems using the concept of algebraic operations of matrices.	I	1
2	Use the concept of adjoint of a matrix to find the inverse of a matrix.	I	1
3	Solve system of linear equations using matrices. Use suitable software to demonstrate the geometric meaning of solution of system of linear equations.	I	1
4	Solve examples related to 1st rule of derivative, working rules.	II	1
5	Solve examples of derivative related to Chain Rule, Implicit functions.	II	1
6	Solve the examples derivative of Parametric functions and second order derivative of simple functions.	II	1

S. No.	Practical Outcomes (PrOs)/Tutorials	Unit No.	Approx. Hrs. required
7	Use concept of derivative to solve the problems related to velocity, acceleration and Maxima-Minima of given simple functions. Use suitable graphical software to visualize the concept of maxima-minima of function.	II	1
8	Solve examples of integration using working rules, standard forms of integration and method of substitution.	III	1
9	Use the concept of integration by parts to solve related problems. Solve problems related to definite integral using properties.	III	1
10	Apply the concept of definite integration to find area and volume.	III	1
11	Solve problems of the order, degree of differential equations and Variable Separable method.	IV	1
12	Apply the concept of linear differential equations to solve given differential equation. Explain the various applications of differential equations in engineering and real life.	IV	1
13	Solve problems related to algebraic operations of complex numbers, conjugate, modulus and inverse of given complex number.	V	1
14	Solve problems related to polar form of a complex number, argument of complex number, De Moivre's Theorem and square root of a given complex number.	V	1
			14 Hrs.

Note

*i. More **Practical Exercises/Tutorials** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

*ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises/Tutorials** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs/Tutorials	Weightage in %
	Geometric Thinking: Comprehend geometric concepts to prove theorems by applying apt results to solve well defined Engineering problems.	
1	Solve problems based on derivative/integration and interpret geometrically the obtained solution.	40
2	Solve problems involving area and volume through integrals and interpret geometrically.	20
3	Perform basic operations of complex numbers geometrically.	30
4	Interpret the result and conclude.	10
Total		**100**

S. No.	Sample Performance Indicators for the PrOs/Tutorials	Weightage in %
S. No.	Sample Performance Indicators for the PrOs/Tutorials	Weightage in %
	Algebraic Thinking: Create, interpret, use, and analyze expressions, equations, and inequalities in a variety of contexts.	
1	Represent, interpret, and solve variable expressions, equations, and inequalities.	60
2	Write expressions in equivalent forms to solve problems.	20
3	Interpret the result and conclude.	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Computer System & LCD Projector	3,5,6,10,12,13
2	Scientific Calculator (Display type: Natural Display Algebraic input logic: Natural V.P.A.M. Significant function: 10+2.	5,9,11

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow ethical practices.
c) Realize importance of green Mathematics.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher
to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I **Matrices**	1a. Solve simple problems using the concept of algebraic operations of matrices. 1b. Apply the concept of adjoint of a matrix to find the inverse of a matrix. 1c. Investigate the solution of system of linear equations using matrices.	1.1 Concept of Matrix 1.2 Types of Matrices 1.3 Addition, Subtraction and multiplication by scalar of matrices 1.4 Product of two matrices 1.5 Adjoint and Inverse of a matrix of order 2X2 and 3X3. 1.6 Solution of Simultaneous linear equations of two variables.
Unit – II **Differentiation and its Applications**	2a. Apply the working rules and standard forms of differentiation to find the derivative of simple functions. 2b. Invoke the concept of Chain Rule to find the derivative of simple functions. 2c. Find the derivative of Implicit and Parametric functions. 2d. Apply the standard forms and rules of derivative to find the second order derivative of simple functions. 2e. Apply the concept and rules of derivative to solve the problems related to velocity, acceleration and Maxima-Minima of given simple functions.	2.1. Concept and Definition of Differentiation 2.2. Working rules: Sum, Product, Division 2.3. Chain Rule 2.4. Derivative of Implicit functions 2.5. Derivative of Parametric functions 2.6. Logarithmic Differentiation 2.7. Successive Differentiation up to second order 2.8. Applications: Velocity, Acceleration, Maxima & Minima of given simple functions.
Unit– III **Integration and its Applications**	3a. Apply the working rules and standard forms of integration to find the integral of simple functions. 3b. Find the integral of simple functions using the method of substitution and integration by parts. 3c. Solve problems related to definite integral using properties. 3d. Apply the rules and standard forms of integration to solve the problems related to area and volume.	3.1 Concept and Definition of Integration. 3.2 Working rules and Integral of standard functions. 3.3 Method of substitution. 3.4 Integration by parts. 3.5 Definite Integral and its properties. 3.6 Applications: Area and volume. (Simple problems)
Unit– IV	4a. Find the order and degree of differential equations.	4.1 Concept and Definition, Order and Degree of differential equation.

Differential Equations	4b. Solve Differential Equations related to Variable Separable method. 4c. Solve given linear differential equations	4.2 Solution of DE of first degree and first order by Variable Separable method. 4.3 Solution of linear Differential equation.
Unit– V **Complex Numbers**	5a. Convert the complex form into a+ib form using algebraic operations of complex numbers. 5b. Find conjugate, modulus and inverse of a given complex number. 5c. Convert the given complex number into polar form using the concept of modulus and argument. 5d. Use De Moivre's Theorem to simplify mathematical expressions. 5e. Find the square root of a given complex number and cube root of unity.	5.1 Concept of Complex number. 5.2 Algebra of Complex numbers. 5.3 Conjugate, Modulus and inverse of Complex numbers. 5.4 Argument and Polar form of a Complex number. 5.5 De Moivre's Theorem and related simple examples. 5.6 Square root of a Complex number and cube root of unity.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Matrices	09	4	6	6	16
II	Differentiation and its Applications	10	4	6	6	16
III	Integration and its Applications	10	4	4	6	14
IV	Differential Equations	06	2	4	6	12
V	Complex Numbers	07	2	6	4	12
Total		**42**	**16**	**26**	**28**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of theUOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may varyslightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare

reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Identify engineering problems based on real world problems relevant to content of the unit and solve these problems in the light of free tutorials available on the internet.
b) Explore the opportunity to visit Science city, ISRO or nearby Science centers.
c) Explore the opportunity to visit Mathematics Lab Virtually.
d) Prepare charts showing formulas of differentiation.
e) Prepare charts showing formulas of integrations.
f) Use Graphing calculator to plot the graph of solutions explaining Engineering applications.
g) Communicate mathematical thinking coherently and clearly to other students, peers, and others.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessedusing different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Explore the possibility for understanding the Biosphere through Mathematics.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the microproject should be about **14**-**16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) **Charts:** Prepare the Charts of formulae for Matrix, Differentiation, Integration, Complex Numbers.
b) **Charts:** Compare last weather conditions with current weather to predict future weather through chart.
c) **Models:** Prepare the cardboard models based on real world applications of derivatives.

d) **Presentation/Seminar:** Prepare a presentation/seminar on any relevant topic of interdisciplinary nature.
e) **History of Mathematics**: Prepare a write up on the Historical path of Calculus.
f) **Solution of system of linear equations:** Form the system of linear equations up to three variables for the given electrical circuit using matrices and solve it.
g) **Maxima and Minima:** Find a real-world problem related to finding area/volume, form the corresponding function and find maxima/minima. For example, maximize the volume of a box made of a rectangle tin sheet by cutting off squares of same size from each corner and folding up.
h) Slope of tangent: Find the slope of tangent for the given curves at a given point using derivative and verify using suitable software.
i) Area/Volume: Find the area of a given closed regain or volume of revolution for a given function using integration and verify using suitable software.
j) Solution of Differential equation: Form differential equations for real-world problems and plot the graph using suitable software with geometrical interpretation.
k) Geometrical representation of complex numbers: Formulate the geometrical representation of addition, subtraction, multiplication, etc. and explain using suitable software.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Elementary Engineering Mathematics	B. S. Grewal	Khanna Publishers,15th Edition. ISBN: 978-81-7409-257-1
2	Engineering Mathematics (Third edition).	Croft, Anthony	Pearson Education, New Delhi, 2014. ISBN 978-81-317-2605-1
3	Calculus and Its Applications	Marvin L. Bittinger David J. Ellenbogen Scott A. Surgent	Addison-Wesley 10th Edition ISBN-13: 978-0-321-69433-1
4	Calculus and Analytic Geometry	G. B. Thomas, R. L. Finney	Addison Wesley, 9th Edition, 1995. ISBN 978-8174906168
5	Understanding Engineering Mathematics	John Bird	Routledge; 1st edition ISBN 978-0415662840
6	Advanced Engineering Mathematics	Krezig, Ervin	Wiley Publ., New Delhi,2014, ISBN: 978-0-470-45836-5

14. SOFTWARE/LEARNING WEBSITES

a) https://www.youtube.com/channel/UCLJVrQyPYsseCf78QWCDsvA/featured (YouTube Channel of DTEGUJ)
b) https://www.geogebra.org/?lang=en

c) https://nios.ac.in/online-course-material/sr-secondary-courses/mathematics-(311).aspx
d) www.dplot.com/ - DPlot
e) www.wolfram.com/mathematica/
f) www.easycalculation.com
g) www.scilab.org/ - SCI Lab
h) https://ncert.nic.in/textbook.php (NCERT Textbooks of Mathematics 11th and 12th Science)
i) https://www.desmos.com/

15. PO-COMPETENCY-CO MAPPING

Semester II	Engineering Mathematics (Course Code:C4320002)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency .	Solve broad-based technology problems using the principles of Engineering mathematics.						
Course Outcomes CO a) Demonstrate the ability to Crack engineering related problems based on Matrices	3	1	-	-	-	-	1
CO b) Demonstrate the ability to solve engineering related problems based on applications of differentiation	3	1	1	-	-	-	1
CO c) Demonstrate the ability to solve engineering related problems based on applications of integration	3	1	1	-	-	-	-
CO d)Develop the ability to apply differential equations to	3	1	1	-	-	-	1

significant applied problems							
CO e) Represent complex numbers algebraically and geometrically for solving engineering related problems	3	1	-	-	-	-	-

*Legend: '**3**' for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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NITTTR Resource Persons

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