Board of Studies in Mathematics (UG)

UNIVERSITY OF KERALA

SYLLABUS

For 2023 admission onwards

1) First Degree Programme in Mathematics (Core)-Under Choice Based Credit and Semester System

2) Complementary Course in Mathematics for the First Degree Programme in Computer Applications (BCA)

3) Complementary Course in Mathematics for the First Degree Programme in Chemistry and Industrial Chemistry

4) Complementary Course in Mathematics For the First Degree Programme in Physics and Computer Applications

5) Complementary Course in Mathematics for the First Degree Programme in Computer Science

6) Complementary Course in Mathematics for the First Degree Programme in Electronics

First Degree Programme in

MATHEMATICS

Under Choice Based Credit and Semester System

SYLLABUS

MATHEMATICS (CORE)

For 2023 admission onwards

SCHEME AND STRUCTURE OF CORE COURSES

Sem	Course Code	Course Title	Instructional Hours per Week	Credit	Maximum Marks		
					CA	ESA	Total
I	MM 1141	Methods of Mathematics	4	4	20	80	100
II	MM 1221	Foundations of Mathematics	4	3	20	80	100
III	MM 1341	Number Theory and Multivariable Calculus	5	4	20	80	100
IV	MM 1441	Theory of Matrices and Multivariable Calculus	5	4	20	80	100
V	MM 1541	Real Analysis I	5	4	20	80	100
	MM 1542	Complex Analysis I	4	3	20	80	100
	MM 1543	Abstract Algebra - Group Theory	4	4	20	80	100
	MM 1544	Differential Equations	3	2	20	80	100
	MM 1545	Linear Algebra	4	4	20	80	100
	MM 1551	Open Course	3	2	20	80	100
	-	Mathematics Software - LaTeX Practical (Examination in sixth semester)	2	-	-	-	-
VI	MM 1641	Real Analysis II	5	4	20	80	100
	MM 1642	Complex Analysis II	4	3	20	80	100
	MM 1643	Abstract Algebra - Ring Theory	4	3	20	80	100
	MM 1644	Integral Equations	4	3	20	80	100
	MM 1651	Elective Course	3	2	20	80	100
	MM 1645	Python (Practical Examination only for LaTeX and Python)	3	4	20	80	100
	MM 1646	Project	2	4	-	100	100

STRUCTURE OF OPEN COURSES

Sem	Course Code	Course Title	Instr. Hrs Per week	Credit
V	MM 1551.1	Operations Research	3	2
V	MM 1551.2	Business Mathematics	3	2
V	MM 1551.3	Basic Mathematics	3	2

STRUCTURE OF ELECTIVE COURSES

Sem	Course Code	Course Title	Instr. Hrs Per week	Credit
VI	MM 1661.1	Graph Theory	3	2
VI	MM 1661.2	Fractal Geometry	3	2
VI	MM 1661.3	Numerical Methods	3	2

PROGRAMME SPECIFIC OUTCOMES (PSO) FOR FIRST DEGREE PROGRAMME IN MATHEMATICS (CORE)

Programme Specific Outcomes

PSO1 Acquire knowledge in functional areas of Mathematics and apply in all the fields of learning.

PSO2 Equip the student with skills to analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof.

PSO3 Employ mathematical ideas encompassing logical reasoning, analytical, numerical ability, theoretical skills to model real-world problems and solve them.

PSO4 Develop critical thinking, creative thinking, self confidence for eventual success in career.

PSO5 Analyze, interpret solutions and to enhance their Entrepreneurial skills, Managerial skill and leadership

PSO6 Recognize the need for life long learning and demonstrate the ability to explore some mathematical content independently.

PSO7 To prepare the students to communicate mathematical ideas effectively and develop their ability to collaborate both intellectually and creatively in diverse contexts.

PSO8 Imbibe effective scientific and/or technical communication in both oral and writing.

PSO9 Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences.

Semester I

Methods of Mathematics

Code: MM 1141 Instructional hours per week: 4

No. of Credits 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Define maxima, minima, critical points and points of inflection.

CO2 Apply the concept of differentiation in real life situation.

CO3 Explain logic and various proof techniques.

CO4 Illustrate decomposition of an integer into prime factors

Module I - Methods of Differential Calculus (36 Hours)

In the beginning of this module, the basic concepts of calculus like limit of functions especially infinite limits and limits at infinity, continuity of functions, basic differentiation, derivatives of standard functions, implicit differentiation etc. should be reviewed with examples.

The above topics which can be found in chapter 2 of text [1] below are not to be included in the end semester examination. A maximum of 5 hours should be devoted for the review of the above topics.

After this quick review, the main topics to discuss in this module are the following:
Differentiating equations to relate rates, how derivatives can be used to approximate nonlinear functions by linear functions, error in local linear approximation, differentials; Increasing and decreasing functions and their analysis, concavity of functions, points of inflections of a function and applications, finding relative maxima and minima of functions and graphing them, critical points, first and second derivative tests, multiplicity of roots and its geometrical interpretation, rational functions and their asymptotes, tangents and cusps on graphs; Absolute maximum and minimum, their behavior on various types of intervals, applications of extrema problems infinite and infinite intervals, and in particular, applications to Economics; Motion along a line, velocity and speed, acceleration, Position - time curve, Rolle's, Mean Value theorems and their consequences, Exponential and

Logarithmic functions, Derivatives of Logarithmic functions, Indeterminate forms and L'Hôpital's rule.

The topics to be discussed in this module can be found in chapter 2 sections 2.8, 2.9 (sections 2.1 to 2.7 are for review purpose only) , 3 all sections, and 6 Sections 6.1, 6.2 excluding logarithmic integration, and section 6.5 of text [1] below.

Module Specific Outcomes

- Understand the concept rate of change, differentials, local linear approximation
- Define maxima, minima, critical points and points of inflection
- Establish relationships between the sign of f' and f'' and the shape of the graph of f
- Cite examples for functions with maxima and minima with one extrema, with no extrema
- Draw appropriate graphs neatly and correctly

Module II - Methods of Logic and Proof (18 Hours)

The following are the main topics in this module:
Statements, logical connectives, and truth tables, conditional statements and parts of it, tautology and contradiction, using various quantifiers like universal and existential quantifiers in statements, writing negations, determining truth value of statements;
Proof: Various techniques of proof like inductive reasoning, counter examples, deductive reasoning, hypothesis and conclusion, contrapositive statements, converse statements, contradictions, indirect proofs

The topics to be discussed in this module can be found in Chapter 1 sections 1 to 4 of text [2] below.

Module Specific Outcomes

- Identify logical connectives, truth tables, conditional statements
- Explain various proof techniques

Module III – Methods of Number Theory (18 Hours)

The following are the main topics in this module:

Mathematical induction, The division algorithm, Pigeonhole principle, divisibility relations, inclusion-exclusion principle, prime and composite numbers, infinitude of primes, GCD, linear combination of integers, pairwise relatively prime integers, the Euclidean algorithm for finding GCD, the fundamental theorem of arithmetic, canonical decomposition of an integer into prime factors, LCM

The topics to be discussed in this module can be found in Chapter 1 section 1.3, Chapter 2 sections 2.1, 2.5 and Chapter 3 sections 3.1 to 3.4 of text [3] below. The topics from the subsection 'A Number-Theoretic Function' onwards are excluded for examination. But Theorem 2.12 and Lemma 2.25 to be discussed. The subsections marked as optional, Theorems 3.1, 3.2, 3.3, 3.12, 3.14, and Lemma 3.2 are excluded for examination.

Module Specific Outcomes

- Explain the concept of Mathematical induction
- Establish the canonical decomposition of integer into prime factors

Texts

Text 1 H Anton, I Bivens, S Davis, *Calculus Late Transcendentals*, 10$^{\text{th}}$ Edition, John Wiley & Sons.

Text 2 S R Lay, *Analysis with an Introduction to Proof*, 5$^{\text{th}}$ Edition, Pearson Education Limited

Text 3 Thomas Koshy, *Elementary Number Theory with Applications*, 2$^{\text{nd}}$ Edition, Academic Press.

e-resources

1. https://www.khanacademy.org
2. https://www.geogebra.org/m/z3jEUrvv

References

Ref. 1 G B Thomas, R L Finney, *Calculus*, 9th Edition, Addison-Weseley Publishing Company.

Ref. 2 Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12^{th} Edition, Addison-Weseley Publishing Company.

Ref. 3 J Stewart, *Calculus with Early Transcendental Functions*, 7^{th} Edition, Cengage India Private Limited.

Ref. 4 J P D'Angelo, D B West, *Mathematical Thinking - Problem Solving and Proofs*, 2nd Edition, Prentice Hall.

Ref. 5 Daniel J Velleman, *How to Prove it: A Structured Approach*, 2nd Edition, Cambridge University Press.

Ref. 6 Elena Nardi, Paola lannonne, *How to Prove it: A brief guide for teaching Proof to Year 1 mathematics undergraduates*, University of East Anglia, Centre for Applied Research in Education.

Ref. 7 G A Jones, J M Jones, *Elementary Number Theory*, Springer.

Semester II

Foundations of Mathematics

Code: MM 1221 Instructional hours per week: 4

No. of credits: 3

Course Outcomes: After the completion of the course the students will be able to

CO1 Describe the integration of a function and learn its physical interpretation through various examples.

CO2 Demonstrate various applications of integration.

CO3 Compute tangent lines to polar curves, arc length and area.

CO4 Sketch conic sections such as parabola, ellipse and Hyperbola.

CO5 Distinguish the cylindrical and spherical coordinate systems.

Module I - Foundations of Integral Calculus (36 Hours)

The module should begin with revising integration techniques, like integration by substitution, fundamental theorem of calculus, integration by parts, integration by partial fractions, integration by substitution and the concept of definite integrals. The above topics which can be found in chapter 4 and 7 of text [1] below are not to be included in the end semester examination. A maximum of 5 hours should be devoted for the review of the above topics. After this quick review, the main topics to discuss in this module are the following: Finding position, velocity, displacement, distance traveled of a particle by integration, analysing the distance-velocity curve, position and velocity when the acceleration is constant, analysing the free-fall motion of an object, finding average value of a function and its applications;
Area, volume, length related concepts: Finding area between two curves, finding volumes of some three dimensional solids by various methods like slicing, disks and washers, cylindrical shells, finding length of a plane curve, surface of revolution and its area;
Work done : Work done by a constant force and a variable force, relationship between work and energy;
Relation between density and mass of objects, center of gravity, Pappus theorem and related problems

Fluids, their density and pressure, fluid force on a vertical surface.
Introduction to Hyperbolic functions and their applications in hanging cables;
Improper integrals, their evaluation, applications such as finding arc length and area of surface.

The topics to be discussed in this module can be found in chapter 4 sections 4.7 and 4.8, chapter 5 sections 5.1 to 5.8, and chapter 6 section 6.8 (Chapter 4 sections 4.1 to 4.6 and 4.9 and chapter 7 are for review purpose only) of text [1] below.

Module Specific Outcomes

- Explain how to find velocity, displacement, distance traveled using integration
- Computing area, volume, length, arc length, area of surfaces using integration technique
- Identifying the relation between work and energy

Module II - Foundations of co-ordinate geometry (18 Hours)

The following are the main topics in this module:
Parametric equations of a curve, orientation of a curve, expressing ordinary functions parametrically, tangent lines to parametric curves, arc length of parametric curves;
Polar co-ordinate systems, converting between polar and rectangular co-ordinate systems, graphs in the polar co-ordinate system, symmetry tests in the polar co-ordinate system, families of lines, rays, circles, other curves, spirals;
Tangent lines to polar curves, arc length of the curve, area, intersections of polar curves;
Conic sections: definitions and examples, equations at standard positions, sketching them, asymptotes of hyperbolas, translating conics, reflections of conics, applications, rotation of axes and eliminating the cross product term from the equation of a conic, polar equations of conics, sketching them, applications in astronomy such as Kepler's laws, related problems

The topics to be discussed in this module can be found in Chapter 10 (all sections) of text [1] below.

Module Specific Outcomes

- Describing polar coordinate system, conversion between rectangular and polar coordinate system
- Determining curves in polar coordinate system
- Tracing the graphs of conic sections

Module III - Foundations of vector calculus (18 Hours)

To begin with, the three dimensional rectangular co-ordinate system should be discussed and how distance is to be calculated between points in this system. Basic operations on vectors like their addition, cross and dot products should be introduced next. The concept of projections of vectors and the relation with dot product should be given emphasize. Equations of lines determined by a point and vector, vector equations in lines, equations of planes using vectors normal to be should be discussed. Quadric surfaces which are three dimensional analogues of conics should be discussed next. Various co-ordinate systems like cylindrical, spherical should be discussed next with the methods for conversion between various co-ordinate systems.

The topics to be discussed in this module can be found in Chapter 11 (all sections) of text [1] below.

Module Specific Outcomes

- Understand basic vector operations
- Constructing vector equations of lines
- Explain various coordinate systems

Texts

Text 1 H Anton, I Bivens, S Davis, *Calculus Late Transcendentals*, 10th Edition, John Wiley & Sons.

e-resourses

1. https://www.geogebra.org/m/ngfvakga
2. https://www.geogebra.org/m/AzVR5uU7
3. https://www.geogebra.org/m/yyu2my9w

References

Ref. 1 G B Thomas, R L Finney, *Calculus*, 9th Edition, Addison-Weseley Publishing Company.

Ref. 2 Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12th Edition, Addison-Weseley Publishing Company.

Ref. 3 J Stewart, *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited.

Semester III

Number Theory and Multivariable Calculus

Code: MM 1341 Instructional hours per week: 5

No. of credits: 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Explain the concept of congruence

CO2 Analyse linear system of congruence equations

CO3 Define the concept of limit, continuity, derivative of vector valued functions

CO4 Illustrate various applications of multivariable calculus.

Module I - Congruence relations in integers (18 Hours)

The topic of elementary number theory is introduced for further developing the ideas in abstract algebra. Towards defining the congruence classes in $\mathbb{Z}$, we begin with defining the congruence relation. Its various properties should be discussed, and then the result that no prime of the form $4n + 3$ is a sum of two squares should be discussed. The other topics in this module are the following:
Defining congruence classes, complete set of residues, modular exponentiation, finding reminder of big numbers using modular arithmetic, cancellation laws in modular arithmetic, linear congruences and existence of solutions, modular inverses,
Certain tests for divisibility - The numbers here to test are powers of 2, 3, 5, 9, 10, 11, testing whether a given number is a square;
Linear system of congruence equations, Chinese Remainder Theorem and some applications;

The topics to be discussed in this module can be found in Chapter 4 sections 4.1 and 4.2, Chapter 5 section 5.1, Chapter 6 section 6.1 of text [2] below. The subsections marked as optional and 'The monkey and coconut puzzle revisited' are excluded for examination.

Module Specific Outcomes

- Defining congruence classes, complete set of residues

- Determining whether a given number is a square

Module II - Vector valued functions (30 Hours)

Towards going to the calculus of vector valued functions, we define such functions. The other topics in this module are the following:
Parametric curves in the three dimensional space, limits, continuity and derivatives of vector valued functions, geometric interpretation of the derivative, basic rules of differentiation of such functions, derivatives of vector products, integrating vector functions, length of an arc of a parametric curve, change of parameter, arc length parametrizations, various types of vectors that can be associated to a curve such as unit vectors, tangent vectors, binormal vectors, definition and various formulae for curvature, the geometrical interpretation of curvature, motion of a particle along a curve and geometrical interpretation of various vectors associated to it, various laws in astronomy like Kepler's laws and problems.

The topics to be discussed in this module can be found in chapter 12 (all sections) of text [1] below.

Module Specific Outcomes

- Computing limits, continuity, derivatives and integrals of vector valued functions
- Identifying geometric interpretation of curvature

Module III - Multivariable Calculus (42 Hours)

After introducing the concept of functions of more than one variable, the sketching of them in three dimensional cases with the help of level curves should be discussed. Countours and level surface plotting also should be discussed. The other topics in this module are the following:
Limits and continuity of Multivariable functions, various results related to finding the limits and establishing continuity, continuity at boundary points, partial derivatives of functions, partial derivative as a function, its geometrical interpretation, implicit partial differentiation, changing the order of partial differentiation and the equality conditions; Differentiability of a multivariate function, differentiability of such a function implies its continuity, local linear approximations, chain rules - various versions, directional derivative and differentiability, gradient and its properties, applications of gradients;
Tangent planes and normal vectors to level surfaces, finding tangent lines to intersections of surfaces, extrema of multivariate functions, techniques to find them, critical and saddle points, Lagrange multipliers to solve

extremum problems with constrains.

The topics to be discussed in this module can be found in chapter 13 (all sections) of text [1] below.

Module Specific Outcomes

- Identifying graphs of functions of more than one variable
- Computing partial derivative of a function of more than one variable
- Calculating extrema of multivariate functions

Texts

Text 1 H Anton, I Bivens, S Davis, *Calculus Late Transcendentals*, 10^{th} Edition, John Wiley & Sons.

Text 2 Thomas Koshy, *Elementary Number Theory with Applications*, 2^{nd} Edition, Academic Press.

e-resources

1. https://www.geogebra.org/m/xtbjxwwm
2. https://www.geogebra.org/m/VMa4z2RU
3. https://www.geogebra.org/m/wcjfy77h

References

Ref. 1 G B Thomas, R L Finney, *Calculus*, 9^{th} Edition, Addison-Weseley Publishing Company.

Ref. 2 Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12^{th} Edition, Addison-Weseley Publishing Company.

Ref. 3 J Stewart, *Calculus with Early Transcendental Functions*, 7^{th} Edition, Cengage India Private Limited.

Ref. 4 G A Jones, J M Jones, *Elementary Number Theory*, Springer.

Semester IV

Theory of Matrices and Multivariable Calculus

Code: MM 1441 Instructional hours per week: 5

No. of credits: 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Define the concepts of Matrix operations their algebraic properties, System of linear operations and their Matrix representation, Gauss-Jordan Elimination

CO2 Describe the concepts of Multiple integrals.

CO3 Apply double and triple integrals to solve real life problems.

CO4 Describe the concepts potential functions, line integrals and surface integrals.

Module I - Theory of Matrices (18 Hours)

Introduction to Matrices and Systems of Linear Equations, Echelon form and Gauss-Jordan Elimination, Consistent System of Linear Equations, Matrix operations, Algebraic Properties of Matrix Operations, Linear Independence and non singular Matrices, Matrix inverses and their properties.
The topics to be discussed in this module can be found in Chapter 1 Sections 1.1, 1.2, 1.3, 1.5, 1.6, 1.7 and 1.9 of text [2] below.

Module Specific Outcomes

- Observing system of equations as matrix equations
- Describing algebraic properties of matrix operations

Module II - Multiple integrals (36 Hours)

Here we discuss double and triple integrals and their applications. The main topics in this module are the following:
Double integrals: Defining and evaluating double integrals, its properties, double integrals over non rectangular regions, determining limits of integration, revising the order of integration, area and double integral, double integral in polar coordinates and their evaluation, finding areas using polar double integrals, conversion between rectangular to polar

integrals, finding surface area, surface of revolution in parametric form, vector valued function in two variables, finding surface area of parametric surfaces;
Triple integrals: Properties, evaluation over ordinary and special regions, determining the limits, volume as triple integral, modifying order of evaluation, triple integral in cylindrical co-ordinates, Converting the integral from one co-ordinate system to other; Change of variable in integration (single, double, and triple), Jacobians in two and three variables.
The topics to be discussed in this module can be found in chapter 14 Sections 14.1 to 14.7 of text [1] below.

Module Specific Outcomes

- Calculating area, volume and surface area using multiple integrals
- Interpreting change of variable in integration

Module III - Vector Calculus (36 Hours)

After the differentiation of vector valued functions in the last semester, here we introduce the concept of integrating vector valued functions. Some important theorems are also to be discussed here. The main topics are the following:
Vector fields and their graphical representation, various type of vector fields (inverse-square, gradient, conservative), potential functions, divergence, curl, the ∇ operator, the Laplacian operator ∇^2;
Integrating a function along a curve (line integrals), integrating a vector field along a curve, defining work done as a line integral, line integrals along piecewise-smooth curves, integration of vector fields and independence of path, fundamental theorem of line integrals, line integrals along closed paths, test for conservative vector fields, Green's theorem and applications;
Defining and evaluating surface integrals, their applications, orientation of surfaces, evaluating flux integrals, The divergence theorem, Gauss' Law, Stoke's theorem, applications of these theorems.

The topics to be discussed in this module can be found in chapter 15 sections 15.1 to 15.8 of text [1] below.

Module Specific Outcomes

- Computing integration along curves, closed paths
- Evaluating surface integrals

Texts

Text 1 H Anton, I Bivens, S Davis, *Calculus Late Transcendentals*, 10th Edition, John Wiley & Sons.

Text 2 Lee W. Johnson, R Dean Riess, Jimmy T. Arnold, *Introduction to Linear Algebra*, Fifth Edition, Addison Wesley.

e-resources

1. https://www.geogebra.org/m/g4xzgh8u
2. https://www.geogebra.org/m/Bp2mU8tk
3. https://www.geogebra.org/m/cu3yv7q8
4. https://www.geogebra.org/m/cqak5q98
5. https://www.geogebra.org/m/m7rzymub
6. https://www.geogebra.org/m/vm3jr9my
7. https://www.geogebra.org/m/wvxr8wxr
8. https://www.geogebra.org/m/zQzssykZ
9. https://www.geogebra.org/m/Bx8nFMNc

References

Ref. 1 G B Thomas, R L Finney, *Calculus*, 9th Edition, Addison-Weseley Publishing Company.

Ref. 2 Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12th Edition, Addison-Weseley Publishing Company.

Ref. 3 J Stewart, *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited.

Ref. 4 Gilbert Strang, *Introduction to Linear Algebra* , 5th Edition.

Ref. 5 Gilbert Strang, *Linear Algebra and its Applications*, 4th Edition, Cengage Learning.

Ref. 6 Video lectures of Gilbert Strang Hosted by MITOpenCourseware available at https:/ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Ref. 7 Thomas Banchoff, John Wermer, *Linear Algebra Through Geometry*, 2^{nd} Edition, Springer.

Ref. 8 David C Lay, Linaer algebra, Pearson

Ref. 9 T S Blyth, E F Robertson, Linear Algebra, Second Edition, Springer.

Ref. 10 K Hoffman, R Kunze, Linear algebra, PHI.

Semester V

Real Analysis I

Code: MM 1541 Instructional hours per week: 5

No. of credits: 4

Course Outcomes: After the completion of the course the students will be able to

CO1 understand the fundamental properties of Real Numbers that corroborate the formal development of Real Analysis.

CO2 demonstrate and understand the theory of real sequences and series.

CO3 ability to check the convergence or divergence of different sequences and series.

CO4 understand and perform simple proofs.

CO5 understand the concepts related to limit of functions.

Module I - Real numbers (18 Hours)

This module deals with the fundamental properties of real numbers. In the beginning of this module, finite and infinite sets and countable and uncountable sets should be discussed. A quick review of these topics can be done from 1.3.1 and 1.3.6 of text [1] and are not to be included in the end semester examination. After the quick review the main topics to discuss in the module are the following:
Absolute value and its properties, The real line, neighborhood and examples, Suprima, Infima and Completeness property of $\mathbb{R}$. Applications of supremum and infimum - Archimedean Property, Existence of $\sqrt{2}$ and Density of rational and irrational numbers. Intervals and its characterization theorem, Nested interval property and uncountability of $\mathbb{R}$.

All the topics in Chapter 2 of text [1] from 2.2 to 2.5 (up to Theorem 2.5.4), need to be discussed in this module.

Module Specific Outcomes

- Understand more about the number system especially rational and real numbers
- Understand the fundamental properties of Real Numbers that corroborate the formal development of Real Analysis

Module II - Sequences (27 Hours)

In this module the following topics are included: sequences and their limits, Tails of sequences and examples. Limit theorems, Monotone sequences, the calculation of square roots and the Euler number. Subsequences and Bolzano-Weierstrass theorem, Cauchy criterion.

All the topics in chapter 3 of text [1] from 3.1 to 3.4 (Excluding limit superior and limit inferior) and 3.5 (up to 3.5.6, exclude contractive sequences), need to be discussed in this module.

Module Specific Outcomes

- Demonstrate and understand the theory of real sequences.
- Ability to check the convergence or divergence of different sequences.

Module III - Series (27 Hours)

Infinite series, convergence, n^{th} term test, Cauchy criterion for series, harmonic series, p-series, alternating harmonic series.

All the above topics in Chapter 9 of text [2] from sections 9.4.4, 9.5 and 9.6, need to be discussed.

Module Specific Outcomes

- Demonstrate and understand the theory of real series.
- Ability to check the convergence or divergence of different series.

Module IV - Limit of Functions (18 Hours)

The following topics are to be discussed in this module. Cluster point, definition of limit of functions, sequential criteria for limits, divergence criteria. Limit theorems, squeeze theorem, One sided limits, Limit at infinity.

All the above topics in Chapter 4 of text [1]need to be discussed.

Module Specific Outcomes

- Understand the topic limit of functions in the conceptual level.
- Analyze the proof of different theorems related to limit of functions and be able to use the concepts in the intellectual level.

Texts

Text 1 R G Bartle, D Sherbert, *Introduction to Real Analysis*, 4^{th} Edition, John Wiley & Sons.

Text 2 H Anton, I Bivens, S Davis, *Calculus*, 10^{th} Edition, John Wiley & Sons.

References

Ref. 1 W. Rudin, *Principles of Mathematical Analysis*, Second Edition, McGraw-Hill.

Ref. 2 Stephen Abbot, *Understanding Analysis*, 2^{nd} Edition, Springer.

Ref. 3 Terrence Tao, *Analysis I*, Hindustan Book Agency.

Semester V

COMPLEX ANALYSIS - I

Code: MM 1542 Instructional hours per week: 4

No.of credits: 3

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

CO1 Understand the algebraic operations of complex numbers, complex functions.

CO2 Understand the limits, continuity and differentiablilty of complex functions.

CO3 Analyze analytic functions and other elementary functions.

CO4 Apply contour integration, Cauchy's theorem and Cauchy's integral formula.

Module I (16 Hours)

Complex Numbers and Complex plane: Complex Numbers and Their Properties, Complex plane, Polar form of Complex Numbers, Powers and Roots, the Set of Points in the Complex Plane and Applications.

Complex Functions and Mappings: Complex Functions, Complex Functions as Mappings, Limits and Continuity.

The topics to be discussed in this module can be found in Chapter 1, Sections 1.1, 1.2, 1.3, 1.4, 1.5, 1.6 -(Only Quadratic formula); Chapter 2, Sections 2.1 -(up to exponential form of a complex number), 2.2 (parametric curves in the complex plane - including Definition 2.3, common parametric curves in the Complex Plane - line, line segment, ray, circle are only to be discussed), 2.6.1, 2.6.2 (Excluding "Example 6 - discontinuity of principal square root function, Branches, Branch cuts, Points and Applications") of Text [1] below.

Module Specific Outcomes

- Understand the algebraic operations in the set of complex numbers and calculus of functions of a complex variable.
- Understand the polar representation of complex numbers.
- Understand the parametrization of complex curves.

Module II (28 Hours)

Analytic Functions and Elementary Functions: Differentiability and Analyticity, Cauchy - Riemann Equation, Harmonic Functions

Elementary Functions: Exponential and Logarithmic functions, Complex powers, Trigonometric and Hyperbolic Functions.

The topics to be discussed in this module can be found in Chapter 3 - Sections 3.1, 3.2, 3.3; Chapter 4 - Sections 4.1, 4.2, 4.3 (excluding trigonometric equations, modulus, zeros, analyticity, trigonometric mapping), 4.3.2. of Text [1] below.

Module Specific Outcomes

- Understand the concepts of differentiability, analyticity and Cauchy Riemann equations of complex functions.
- Understand the concept of Harmonic functions and harmonic conjugate.
- Understand the properties of elementary complex functions.

Module III (28 Hours)

Integration in the Complex Plane: Complex Integrals, Cauchy - Goursat Theorem, Independence of Path, Cauchy's Integral Formula and Their Consequences.

The topics to be in this module can be found in Chapter 5 - Sections 5.1, 5.2 (excluding the proof of a bounding theorem), 5.3 (excluding the proof of Cauchy Theorem, Theorem 5.3, Theorem 5.4), 5.4 (Some conclusions 5, 6, 7 - proof need not be discussed and exclude example 5), 5.5.1 (excluding proof of Theorems 5.10, 5.15, 5.16) of Text [1] below.

Module Specific Outcomes

- Understand the idea of complex contour integration
- Learn Cauchy's theorem and Cauchy's integral formula and their consequences in contour integration
- Learn Fundamental Theorem and other theorems related to contour integrals.

Text

Text 1 Dennis G Zill, Patric D Shanahan, *A First Course in Complex Analysis with Applications*, Jones and Bartlett Publishers (2003).

References

Ref. 1 James Ward Brown and Ruel V Churchill, *Complex Variables And Applications*, Eighth Edition, McGraw Hill International Edition.

Ref. 2 Edward B. Saff, Arthur David Snider, *Fundamentals of Complex Analysis with Applications to Engineering and Science*, 3^{rd} Edition, Pearson Education India.

Ref. 3 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} Edition, Wiley-India.

Ref. 4 John H Mathews and Russel W Howell, *Complex Analysis for Mathematics and Engineering*, Sixth Edition, Jones and Bartlett Publishers.

Ref. 5 B S Tyagi, *Functions of A Complex Variable*, Kedar Nath Ram Nath.

Ref. 6 Anant R Shastri, *Basic Complex Analysis of One Variable*, Macmillan.

Ref. 7 Schaum's Outline Series, *Complex Variables.*

Semester V

Abstract Algebra - Group Theory

Code: MM 1543 Instructional hours per week: 4

No. of credits: 4

Course Outcomes: Upon Completion of this Course, students will be able to

CO1 apply algebraic ways of thinking.

CO2 examine abstractly about algebraic structures.

CO3 analyse a given structure in detail.

CO4 compare structures.

Module I (24 Hours)

After stating the concept of binary operations the idea of group can be introduced. The definition of group should be stated and clarified with the help of examples. After discussing various properties of groups, finite groups and group tables should be discussed. The concept of subgroups with various characterizations also should be discussed. After introducing the definition of cyclic groups, various examples and important features of cyclic groups and results on order of elements in such groups should be discussed.

The topics to be discussed in this module can be found in section 2, 4, 5 and 6 of text [1] below. Also, discuss the problems 31,32,35,36,39 in section 4; 41,42,43,45,46,47,51,52,54,55,57 in section 5 and 45,49,51,52,55 in section 6.

Module Specific Outcomes Upon Completion of this Module, students will be able to

- identify the algebraic structures groups, subgroups and cyclic groups.
- explain the properties of groups, subgroups and cyclic groups. contour integration
- analyse an arbitrary cyclic group.
- define the order of a group and its elements.

Module II (24 Hours)

This module starts by defining and analysing various properties of permutation groups which forms one of the most important class of examples for nonabelian, finite groups. After defining operations on permutations, concentrate on Cayley's Theorem. Then, proceed to define the notion of orbits, cycles and Alternating groups. (**Exclude the proof 2 of Theorem 9.15**). Now move on to the concept of cosets and prove one of the most important results in group theory which is the Lagrange's Theorem. Also, Introduce the concept of direct products. (**Exclude the subsection, the structure of finitely generated abelian groups in section 11**).

The topics to be discussed in this module can be found in section 8, 9, 10 and 11 of text [1] below. Also, discuss the problems 36, 46 in section 8; 24, 27(a,b) in section 9; 28, 30, 31, 32, 39, 40, 45 in section 10 and 46 in section 11.

Module Specific Outcomes Upon Completion of this Module, students will be able to

- differentiate the concept of abelian and non-abelian groups.
- identify the relation between an arbitrary group and a permutation group.
- apply Lagrange's Theorem.
- develop the idea of direct products.

Module III (24 Hours)

In this module introduce the idea of homomorphisms of groups. Properties of homomorphisms should be discussed in detail. Then factor groups are introduced along with the computation of factor groups. The fundamental homomorphism Theorem and the normal subgroups must also be included here. In the subsection, normal subgroups and inner automorphism, **only the Theorem 14.13 is needed**. Then, the definition of simple group is to be introduced and justify that all groups of prime order are simple. Also explain the statement **without proof of Theorem 15.15**. Then introduce the definition of center of a group with examples. (**Exclude Theorem 15.8 and commutator subgroups**).

The topics to be discussed in this module can be found in section 13, 14 and 15 of text [1] below. Also, discuss the problems 44, 45, 48, 49, 50, 51, 52 in *section 13, 24, 25, 31, 40 in section 14 and 34, 35, 36 in section 15.*

Module Specific Outcomes Upon Completion of this Module, students will be able to

- examine the homomorphism of groups.
- construct factor groups.
- identify the idea of simple group.
- analyse center of a group.

Text

Text 1 John B. Fraleigh, *A First Course in Abstract Algebra*, Seventh Edition, Pearson Education, Inc.

References

Ref. 1 Joseph. A. Gallian, *Contemporary Abstract Algebra*, Eighth Edition, BROOKS/COLE CENGAGE Learning.

Ref. 2 Vijay K. Khanna and S. K. Bhambri, *A Course in Abstract Algebra*, Fifth Edition, Vikas Publications.

Ref. 3 I. N. Herstein, *Topics in Algebra*, Second Edition, Wiley, 2006.

Semester V

Differential Equations

Code: MM 1544 Instructional hours per week: 3

No. of credits: 3

Course Outcomes: After the completion of the course the students will be able to

CO1 Solve linear-first order ordinary differential equations.

CO2 Solve homogeneous and non-homogeneous linear differential equations with constant coeffcients.

In this course, we discuss how differential equations arise in various physical problems and consider some methods to solve first order differential equations and higher order linear equations. For introducing the concepts, text [1] may be used, and for strengthening the theoretical aspects, reference [1] may be used. For discussing numerical solutions of ODE's text[2] may be used.

Module I - First order ODE (18 Hours)

In this module we discuss first order equations and various methods to solve them. Sufficient number of exercises also should be done for understanding the concepts thoroughly. The main topics in this module are the following: Modeling a problem, basic concept of a differential equation, its solution, initial value problems, geometric meaning (direction fields), separable ODE, reduction to separable form, exact ODEs and integrating factors, reducing to exact form, homogeneous and non homogeneous linear ODEs, special equations like Bernoulli equation, orthogonal trajectories, understanding the existence and uniqueness of solutions theorem.

The topics to be discussed in this module can be found in chapter 1 of text [1] below.

Module Specific Outcomes

- Identify the type of a given differential equation and select and apply the appropriate analytical technique for finding the solution of first order and selected higher order ordinary differential equations.
- Evaluate first order differential equations including separable, homogeneous, exact, linear and Bernoulli equation.

- Understand initial value problem and the geometric meaning (direction fields)
- Create and analyze mathematical models using first order differential equations to solve application problems such as circuits, mixture problems, population modeling and orthogonal trajectories.
- Understand the existence and uniqueness of solutions.

Module II - Second and higher order ODE (36 Hours)

As in the first module, we discuss second and higher order equations and various methods to solve them. Sufficient number of exercises also should be done for understanding the concepts thoroughly. The main topics in this module are the following:
Homogeneous linear ODE of second and higher order, initial value problem, basis, and general solutions,Superposition principle, finding a basis when one solution is known, homogeneous linear ODE with constant coefficients (various cases that arise depending on the characteristic equation), differential operators, Euler-Cauchy Equations, existence and uniqueness of solutions with respect to Wronskian for second and higher order ODE, solving non homogeneous ODE via the method of undetermined coefficients, various applications of techniques, solution by variation of parameters. Applications of ODE in Elastic Beams may be excluded.

The topics to be discussed in this module can be found in chapter 2 and 3 of text [1]below.

Module Specific Outcomes

- Solve second and higher order order linear differential equations.
- Determine independence of solutions using the Wronskian.
- Understand the existence and uniqueness of solutions with respect to Wronskian
- Solve non homogeneous equations.
- Solve differential equations using variation of parameters.

Text

Text 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} Edition, Wiley-India

References

Ref. 1 G. F. Simmons, *Differential Equations with Applications and Historical Notes*, Tata McGraw- Hill, 2003

Ref. 2 H Anton, I Bivens, S Davis, *Calculus*, 10^{th} Edition, John Wiley & Sons 19.

Ref. 3 Peter V. O. Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007.

Semester V

Linear Algebra

Code: MM 1545 Instructional hours per week: 4

No. of credits: 4

After discussing matrix theory and system of linear equations in semester 4, in this course we move towards the computational and theoretical principles of linear algebra. The main topics included are elementary vector space concepts and the eigenvalue problem. The prescribed text given below may be used to discuss the contents listed for this course. The proofs of theorems marked optional are not to be included for the examination, but the statements should be demonstrated using sufficient number of examples/exercises. Also the examples and exercises based on programming may be excluded from the examination.

Course Outcomes: After the completion of the course the students will be able to

CO1 Understand elementary concepts in vector space, subspace, linear transformation, eigenvalues and eigenvectors.

CO2 Find the bases and dimension of a vector space.

CO3 Diagonalize various types of matrices.

Module I - Vector space properties of $\mathbb{R}^n$ (30 Hours)

The module begins with an introduction of geometric properties of subsets of $\mathbb{R}^2$ and $\mathbb{R}^3$. After introducing the vector space structure of $\mathbb{R}^n$ and its subsets, the following topics should be discussed: the concept of spanning set, bases and dimension for subspaces of $\mathbb{R}^n$, orthogonal basis and Gram-Schmidt orthogonalization, linear transformation from $\mathbb{R}^n$ to $\mathbb{R}^n$ and matrix of linear transformation, null space and range space, orthogonal transformations on $\mathbb{R}^2$.

The topics to be discussed in this module can be found in chapter 3 of the prescribed text. The proofs of theorems marked optional are not to be included for the examination, but the statements should be demonstrated using sufficient number of examples/exercises. Sections 3.8-3.9 may be omitted.

Module Specific Outcomes

- Understand vector space properties of $\mathbb{R}^n$.
- Find the bases and dimension of subspaces of $\mathbb{R}^n$.
- Find orthogonal bases for subspaces of $\mathbb{R}^n$.
- Determine the matrix of a linear transformation.

Module II - The eigenvalue problem (24 Hours)

This module is intended for making the idea and concepts related to eigenvalue problem and diagonalizing linear transformations. The main topics to be discussed includes:
eigenvalues and the characteristic polynomials, eigenvectors and eigenspaces, geometric multiplicity, similarity transformation and diagonalization, orthogonal matrices, diagonalization of symmetric matrices.

The topics to be discussed in this module can be found in chapter 4 of the prescribed text below. The proofs of results stated in theorem 22 and 23 are not to be included for the examination, but the corollaries and examples following these theorems should be discussed in detail. A review of determinants and its properties can be found in section 4.2 or in chapter 6. Sections 4.2, 4.3, 4.6 and 4.8 are not to be included for the examination.

Module Specific Outcomes

- Solve the eigenvalue problems for matrices.
- Determine the eigenvector and eigenspaces.
- Diagonalize matrices.

Module III - Introduction to general vector spaces (18 Hours)

In this module, using $\mathbb{R}^n$ as a model, we further extend the idea of a vector to include objects such as matrices, polynomials, functions and infinite sequences. After recalling the vector space structure of $\mathbb{R}^n$, we define a general vector space and discuss some examples of general vector spaces. The following topics are to be discussed next; vector space properties, subspaces, spanning set, bases, linear independence, bases and coordinates, dimension, properties of a finite-dimensional vector space.

The topics to be discussed in this module can be found in chapter 5 of the prescribed text. Sections 5.6 to 5.10 may be omitted.

Module Specific Outcomes

- Understand the concepts in general vector space and its subspaces.
- Find the bases and dimension of subspaces.

Text

Text 1 Lee W. Johnson, R. Dean Riess, Jimmy T. Arnold, *Introduction to Linear Algebra*, Fifth edition, Pearson Education, Inc. 2002.

References

Ref. 1 Gilbert Strang, Introduction to Linear Algebra, 5^{th} Edition.

Ref. 2 Video lectures of Gilber Strang Hosted by MITOpenCourseware available at
https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Ref. 3 David C Lay, *Linear Algebra*, Pearson.

Ref. 4 T S Blyth, E F Robertson, *Linear Algebra*, Springer, Second Edition.

Ref. 5 Thomas Banchoff, JohnWermer, Linear Algebra Through Geometry, 2^{nd} Edition, Springer.

Ref. 6 K Hoffman and R Kunze, *Linear Algebra*, PHI.

Semester V

Operations Research (Open Course)

Code: MM 1551.1 Instructional hours per week: 3

No. of credits: 2

Course Outcomes: After the completion of the course the students will be able to

CO1 Find the solutions of LPP using graphical method.

CO2 Solve transportation network problems and assignment problems.

CO3 Able to solve two person games.

CO4 Acquire clear cut knowledge in both theory and application.

Module I - Introduction to OR and Linear Programming(18 Hours)

Origin and development of OR, Nature of OR, Phases of OR and uses and limitations of OR, Mathematical Formulation of the problem, grahical solution method of General LPP(only bounded case to be discussed)

The topics to be discussed in this module can be found in Chapter 1, sections 1.1, 1.2, 1.7, 1.9, Chapter 2, sections 2.1, 2.2 & 2.5. (**Exclude Theorem 2.1, 2.3.1**)

Module Specific Outcomes After Completion of this module, the student should be able to:

- Identify the characteristics of a linear programming problem.
- Formulate linear programming problems.
- Explain the types of solutions of an LPP.
- Solve the LPP graphically.

Module II - Transportation Problem and Assignment problem (18 Hours)

The transportation table, The initial basic feasible solution (The North West corner method, Row minima method, Column minima method,The Matrix minima Method and VAM), Assignment problem : The Assignment algorithm

The topics to be discussed in this module can be found in Chapter 6, sections 6.1, 6.2, 6.3, Chapter 7, sections 7.1 & 7.2. (**Exclude Theorem 6.1 and Theorem 7.1**)

Module Specific Outcomes After Completion of this module, the student should be able to:

- Formulate transportation model.
- Determine the initial basic feasible solutions using various methods.
- Formulate assignment model.

Module III - Project Management and Game theory (18 Hours)

Network Scheduling Basic Concepts, constraints in Network, The calculation in net work, CPM, Game theory Two persons zero sum games.

The topics to be discussed in this module can be found in Chapter 19, sections 19.1, 19.2, 19.3, 19.5, 19.6, Chapter 9, sections 9.1 and 9.2.

Module Specific Outcomes After Completion of this module, the student should be able to:

- Describe networks and the basic concepts associated with it.
- Understand project characteristics and various stages of a project.
- The ability to apply solution concepts to examples of games.

Text

Text 1 Kanti Swarup, P. K. Gupta, Man Mohan, *Operation Research*, Sultan Chand & Sons, 1990.

References

Ref. 1 J. K. Sharma, *Operations Research - Theory and Applications*, Sixth Edition, 2016

Ref. 2 Hamdy Taha, *Operations Research: An Introduction*, Pearson, 10^{th} edition, 2016.

Semester V

Business Mathematics (Open Course)

Code: MM 1551.2 Instructional hours per week: 3

No. of credits: 2

Course Outcomes:

CO1 Develop ability to solve problems related to simple and compound interest which would help the students while appearing for competitive examinations.

CO2 Developing the skill to mathematically formulate the problems of business and economics and solving them using the techniques of Calculus.

CO3 Getting introduced to the concepts of index numbers and its use in business and economics.

CO4 Getting aware of the significance of time series analysis in various realms of economics and business.

Module I - Basic Mathematics of Finance (18 Hours)

Nominal rate of Interest and effective rate of interest, Continuous Compounding, force of interest, compound interest calculations at varying rate of interest, present value, interest and discount, Nominal rate of discount, effective rate of discount, force of discount, Depreciation. (Chapter 8 of Unit I of text [1] - Sections: 8.1, 8.2, 8.3, 8.4. 8.5, 8.6, 8.7, 8.9)

Module Specific Outcomes

- Identifying the difference between simple and compound interest.
- Learning to calculate compound interest where the interest is compounded more than once a year including continuous compounding.
- Understanding the concept of present value and using it in solving problems related to compound interest.
- Learning concepts like force of interest, discount, force of discount, depreciation etc.

Module II - Differentiation and their applications to Business and Economics (18 Hours)

Meaning of derivatives, rules of differentiation, standard results (basics only for doing problems of chapter 5 of Unit 1) (Chapter 4 of unit I of text [1] - Sections: 4.3, 4.4, 4.5, 4.6) Maxima and Minima, concavity, convexity and points of inflection, elasticity of demand, Price elasticity of demand (Chapter 5 of Unit I of text [1] - Sections: 5.1, 5.2, 5.3, 5.4, 5.5. 5.6, 5.7) Integration and their applications to Business and Economics: Meaning, rules of integration, standard results, Integration by parts, definite integration (basics only for doing problems of chapter 7 of Unit 1 of text) (Chapter 6 of unit I of text [1] - Sections: 6.1, 6.2, 6.4, 6.10, 6.11) Marginal cost, marginal revenue, Consumer's surplus, producer's surplus, consumer's surplus under pure competition, consumer's surplus under monopoly (Chapter 7 of unit I of text [1] - Sections: 7.1, 7.2, 7.3, 7.4, 7.5)

Module Specific Outcomes

- Acquiring the ability to find the derivative and integral of various types of functions.
- Using the techniques of differentiation to solve the maximization and minimization problems.
- Learning concepts like marginal revenue, marginal cost, consumer's surplus, producer's surplus, elasticity of demand, monopoly etc and using integration to solve the problems related to these concepts.

Module III - Index Numbers (18 Hours)

Definition, types of index numbers, methods of construction of price index numbers, Laspeyer's price index number, Paasche's price index number, Fisher ideal index number, advantages of index numbers, limitations of index numbers (Chapter 6 of Unit II of text [1] - Sections: 6.1, 6.3, 6.4, 6.5, 6.6, 6.8, 6.16, 6.17) Time series: Definition, Components of time series, Measurement of Trend (Chapter 7 of Unit II of text [1] - Sections: 7.1, 7.2, 7.4)

Module Specific Outcomes

- Getting introduced to indexed numbers its uses, advantages and limitations.
- Studying different types of index numbers, methods to calculate them and differentiate between the scope of the different categories of index numbers.

- Getting an idea of time series analysis, its uses in business and economics, advantages and limitations. Students are expected to master the various techniques used for the time series analysis at the end of this module.

Text

Text 1 B M Agarwal, *Business Mathematics and Statistics*, Vikas Publishing House, New Delhi, 2009.

References

Ref. 1 Qazi Zameeruddin, et al., *Business Mathematics*, Vikas Publishing House, New Delhi, 2009.

Ref. 2 Alpha C Chicny, Kevin Wainwright, *Fundamental methods of Mathematical Economics*, 4^{th} Edition, Mc-Graw Hill.

Semester V

Basic Mathematics (Open Course)

Code: MM 1551.3 Instructional hours per week: 3

No. of credits: 2

This course is specifically designed for those students who might have not undergone a mathematics course beyond their secondary school curriculum. The structure of the course is so as to give an exposure to the basic mathematics tools which found a use in day today life.

Course Outcomes:

CO1 Getting acquainted with various number systems and learning the basic operations on these numbers.

CO2 Learning to perform basic tasks related to ratio and proportions.

CO3 Getting exposed to basic statistical tools.

CO4 To be able to mathematically formulate real life problems and thus solve them.

Module I - Basic arithmetic of whole numbers, fractions and decimals (24 Hours)

Place Value of numbers, standard Notation and Expanded Notation, Operations on whole numbers:
exponentiation, square roots, order of operations, computing averages, rounding, estimation, applications of estimation, estimating product of numbers by rounding, exponents, square roots, order of operations, computing averages;
Fractions: multiplication and division of fractions, applications, primes and composites, factorization, simplifying fractions to lowest terms, multiplication of fractions, reciprocal of fractions, division of fractions, operations of mixed fractions, LCM, Decimal notation and rounding of numbers, fractions to decimals, multiplication of decimals, division of decimals, order of operations involving decimals, Scientific notation of numbers, operations in scientific notations, square and cube roots of numbers, laws of exponents and logarithms The topics to be discussed in this module can be found in chapters 1–3 of text [1] and chapters 1 and 2 of text [2] below.

Module Specific Outcomes

- Learning about the various number systems such as whole numbers, decimals , fractions etc.
- Acquiring the skill to perform various operations such as addition, subtraction, multiplication, division, squaring, finding the square root etc on these numbers.
- Learning about logarithms, exponents and laws related to them.

Module II - Ratios, Proportions, Percents and the Relation Among Them (15 Hours)

Ratio and proportions: Simplifying ratios to lowest terms, ratios of mixed numbers, unit rates and cost, ratios and proportion, similar figures; Percents: Fractions - decimals - percents, converting between these three relation with proportions, equations involving percents, increase and decrease in percent, finding simple and compound interests. The topics to be discussed in this module can be found in chapters 4, 5 of text [1] below.

Module Specific Outcomes

- Getting familiar with ratio and proportions
- Studying the concept of percent in relation to ratio and proportions.
- Getting an idea of simple and compound interests, the difference between them and acquire the ability to solve problems related to simple and compound interest under various conditions.

Module III - Basic Statistics, Simple Equations (15 Hours)

Basic Statistics: Data and tables, various graphs like bar graphs, pictographs, line graphs, frequency distributions and histograms, circle graphs (pie charts), interpreting them, circle graphs and percents, mean, median, mode, weighted mean. Solving simple equations, quadratic equations (real roots only), cubic equations, arithmetic geometric series, systems of two and three equations, matrices and system of equations. The topics to be discussed in this module can be found in chapters 9 of text [1] and chapters 2, 3 of text [2] below.

Module Specific Outcomes

- Learning the importance of data collection, its presentation, analysis and interpretation using basic statistical tools such as bar graphs, pie diagrams, histograms etc.

- Studying the use of different averages such as mean, median and mode and their calculation.
- Learning to formulate real life problems as mathematical equations and mastering techniques to solve these equations.

Texts

Text 1 J Miller, M O'Neil, N Hyde, *Basic College Mathematics*, 2^{nd} Edition, McGraw Hill Higher Education.

Text 2 Steven T Karris, *Mathematics for Business, Science and Technology*, 2^{nd} Edition, Orchard Publications

Reference

Ref. 1 Charles P McKeague, *Basic Mathematics*, 7^{th} Edition, Cengage Learning.

Semester V

Typesetting Scientific Documents with LaTeX

Laboratory hours per week: 2

Course Outcomes: After the completion of the course the student will be able to:

CO1 know the basics of typesetting an article for a scientific publication.

CO2 typeset mathematical expressions in a LaTeXdocument.

CO3 understand the basics of making a slide-show presentation using Beamer.

Note: There will be no theory examination. The practical examination of the same is to be conducted combined with MM1644: Programming with Python during Semester VI examinations.

Module I - Basics of LaTeX (6 Hours)

What is LaTeX, Simple typesetting, Fonts, Type size

(Chapter 1 of Text 1)

Module Specific Outcome

- Learn to typeset a simple document in LaTeX.

Module II - Typesetting Mathematics (12 Hours)

Basics of typesetting *(Section 8.1 complete)*
Single Equations (`equation, equation*, split`)
Group of Equations (`gather, gather*, align, align*, cases`)
Matrices and Determinants (`matrix, pmatrix, bmatrix, vmatrix`)
Putting one over another (`frac, dfrac, int, lim, sum, prod`)

The above topics can be found in 8.1, 8.3.1, 8.3.2, 8.4.2 and 8.4.4 of Text 1.

Basics of typesetting Theorems and `amsthm` package

(*9.1 to 9.2.1 of Text 1*)
Do Exercise questions 4, 5, 6 & 7 of Chapter 9 of Text 2.

Module Specific Outcome

- Learn to typeset basic mathematical expressions in LaTeX.

Module III - Tables and Figures (12 Hours)

Typesetting basic tables. Merge cells using `\multicolumn` (7.2 of Text 1, except the portion using `\renewcommand`)
Inserting pictures using Graphicx package

(12.1.1 to 12.1.3 of Text 1, except the portion on pstricks)
Creating Floating Figures *(11.1.1 of Text 1)*

Module Specific Outcomes

- Become familiar with creating and customising tables.
- Learn to insert pictures in a LaTeX document.

Module IV - Beamer (6 Hours)

What is Beamer. Thinking in terms of frames. Set up a Beamer document. Enhance a Beamer presentation.
(11.1 to 11.4 of Text 2, except the portion using *pstricks*)

Module Specific Outcome

- Learn to create a slide-show presentation using Beamer.

Note: A record should be maintained with at least 10 documents prepared using LaTeX illustrating both their source code and output and is to be submitted at the time of the practical examination.

Texts

Text 1 *The LaTeX Tutorial: A Primer*, by The Tutorial Team, Indian TeXUsers Group, Sayahna Foundation, http://www.sayahna.org, 2020

Text 2 Donald Binder and Martin Erickson, *A student's guide to the study, practice and tools of modern mathematics*, CRC Press, 2010

References

Ref. 1 Hubert Partl, Irene Hyna and Elisabeth Schlegl, *The Not So Short Introduction to LaTeX2$_\varepsilon$*, Tobias Oetiker, Version 6.4, 09 March 2021

Ref. 2 Dilip Datta, *LaTeX in 24 Hours, A Practical Guide for Scientific Writing*, Springer, 2017

Ref. 3 https://www.overleaf.com/learn/latex/Learn_LaTeX_in_30_minutes

Semester VI

Real Analysis II

Code: MM MM 1641 | Instructional hours per week: 5

No. of credits: 4

Course Outcomes: After the completion of the course the student will be able to:

CO1 understand the concepts of continuity, differentiability and integrability, more rigorously than what we done in the previous calculus course.

CO2 understand the fundamental properties of continuous functions on intervals.

CO3 understand the basic theory of derivatives.

CO4 get an exposure to the theory behind the integration.

Module I - Continuous Functions (30 Hours)

In this module the following topics are included: Definition of continuity, sequential criterion, Discontinuity criterion and examples, Combination and composition of continuous functions with examples, Continuous functions on intervals, Uniform Continuity, Lipchitz functions, The continuous Extension theorem.

All the topics in Chapter 5 of text [1] from 5.1 to 5.4 (up to Theorem 5.4.8, exclude Approximation), need to be discussed in this module.

Module Specific Outcomes

- Understand the concepts of continuity, more rigorously than what we done in the previous calculus courses.
- Understand the fundamental properties of continuous functions on intervals.

Module II - Differentiation (30 Hours)

In this module the following topics are included : Definition and examples of differentiability, differentiability of sum and product of functions, chain rule, Caratheodory's theorem, derivative of inverse functions, Interior Extremum theorem, Rolle's theorem, Mean value theorem and its applications, first derivative test for extrema, intermediate value property of derivatives and Darboux's theorem 6.1, 6.2

All the topics in chapter 6 of text [1] from 6.1 to 6.2, need to be discussed in this module.

Module Specific Outcomes

- Understand the concepts of differentiability, more rigorously than what we done in the previous calculus courses
- Concretize the basic theory of differentiation.

Module III - Riemann Integration (30 Hours)

In this module the following topics are included: Definition of Tagged partitions, Riemann sum and Riemann integrability. Properties of Riemann integral, examples and boundedness theorem. Cauchy's criterion for Riemann integrability and Squeeze theorem. Riemann integrability of step functions, continuous functions and monotone functions, additivity theorem. Fundamental Theorem of Calculus (first and second forms).

All the topics in Chapter 7 of text [1] from 7.1 to 7.3 (up to Example 7.3.7), need to be discussed in this module.

Module Specific Outcomes

- Understand the concepts of integrability, more rigorously than what we done in the previous calculus course.
- Get an exposure to the theory behind the integration.

Text

Text 1 R G Bartle, D Sherbert. *Introduction to Real Analysis*, 4^{th} Edition, John Wiley & Sons.

References

Ref. 1 W. Rudin, *Principles of Mathematical Analysis*, Second Edition, McGraw-Hill

Ref. 2 Stephen Abbot, *Understanding Analysis*, 2^{nd} Edition, Springer.

Ref. 3 Terrence Tao, *Analysis I*, Hindustan Book Agency.

Semester VI

Complex Analysis II

Code: MM 1642 | Instructional hours per week: 4

No. of credits: 3

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

CO1 Understand Sequence, Series and Power Series Representation of Complex Functions

CO2 Understand Singular Points, Zeros and Residue of Complex Functions

CO3 Apply Tayor's Series, Laurent Series and Residue Theorem

CO4 Understand Conformal Mapping, Linear Fractional Transformation and Cross-ratio.

Module I (26 Hours)

Sequences and series of complex numbers, their convergence, power series representations of a complex functions and zeros and singular points of complex functions are discussed in this module.

Series and Residues - Sequence and Series, Talyors' Series, Laurent Series, Zeros and Poles.

The topics to be discussed in this module can be found in Chapter 6, Sections 6.1 (excluding the proof of theorems); Section-6.2; Section-6.3 (excluding the proof of Theorem 6.10); Section-6.4 of Text [1] below.

Module Specific Outcomes

- Understand the definitions of convergence and divergece of complex sequences and series.
- Study different tests for the convergence of complex series.
- Understand power series expansion of complex functions with their radius of convergence.

Module II (26 Hours)

This module focused on finding residues at singular points of a complex valued function, applying Residue theorem to evaluate complex integrals and evaluation of some real trigonometric integrals and real improper integrals using Residue theorem.

Residues and Residue Theorem - Residues, Residues at a Simple Pole, Residues at a Pole of Order n, Cauchy's Residue Theorem.

Some Consequences of the Residue Theorem - Evaluation of Real Trigonometric Integrals of the form $\int_0^{2\pi} f(\sin\theta, \cos\theta)\, d\theta$, Cauchy Principal Value, Evaluation of Real Improper Integrals of the form $\int_{-\infty}^{\infty} f(x)\, dx$, $\int_{-\infty}^{\infty} f(x) \cos \alpha x\, dx$ and $\int_{-\infty}^{\infty} f(x) \sin \alpha x\, dx$.

The topics to be discussed in this module can be found in Chapter 6, Sections 6.5, 6.6.1, 6.6.2 (excluding the topic Indented Contours) of Text [1] below.

Module Specific Outcomes

- Identify the nature of singular points of a Complex function and to find the corresponding residues.
- Evaluating contour integrals using Cauchy Residue Theorem.
- Applying Residue Theorem to evaluate real trigenometric and improper integrals.

Module III (20 Hours)

This module aims to define conformal mapping, Linear Mappings, Linear Fractional Transformation and the properties of Linear Fractional Transformation.

Linear Mappings: Translations, Rotations, Magnifications, Linear Mappings.

Conformal Mapping: Definiton, Critical Points, Condition for Conformal Mapping. Linear Fractional Transformation : Definition, Circle Preserving Property, Mapping Lines to Circles, Cross-ratio.

The topics to be discussed in this module can be found in Chapter 2, Section 2.3; Chapter 7, Section 7.1 (excluding the proof of Theorems 7.1, 7.2 and the topic Conformal Mappings Using Tables); Section 7.2 (excluding the proof of Theorem 7.3 and the topic Linear Fractional Transformations as Matrices) of Text [1] below.

Module Specific Outcomes

- Understand different types of mappings
- Understand the concept of Conformal mapping

- Define Linear Fractional Transformation and understanding its properties.

Text

Text 1 Dennis G Zill, Patric D Shanahan, *A First Course in Complex Analysis with Applications*, Jones and Bartlett Publishers (2003).

References

Ref. 1 James Ward Brown and Ruel V Churchill, *Complex Variables And Applications*, 8^{th} Edition, McGraw Hill International Edition.

Ref. 2 Edward B. Saff, Arthur David Snider, *Fundamentals of Complex Analysis with Applications to Engineering and Science*, 3^{rd} Edition, Pearson Education India.

Ref. 3 Erwin Kreyszig, Advanced Engineering Mathematics, 10^{th} Edition, Wiley-India.

Ref. 4 John H Mathews and Russel W Howell, *Complex Analysis for Mathematics and Engineering*, Sixth Edition, Jones and Bartlett Publishers.

Ref. 5 B S Tyagi, *Functions of A Complex Variable*, Kedar Nath Ram Nath.

Ref. 6 Anant R Shastri, *Basic Complex Analysis of One Variable*, Macmillan.

Ref. 7 Schaum's Outline Series, *Complex Variables.*

Semester VI

Abstract Algebra - Ring Theory

Code: MM 1643 — Instructional hours per week: 4

No. of credits: 3

Course Outcomes: Upon Completion of this Course, students will be able to

CO1 construct substructures.

CO2 understand and prove fundamental results and solve algebraic problems using appropriate techniques.

CO3 demonstrate insight into abstract algebra with focus on algebraic theories.

CO4 develop new structures based on given structures.

Module I (36 Hours)

The concept of Rings and Fields which is studied thoroughly with the help of lots of examples. Then move on to Integral Domains. After that, the definition of the characteristic of a ring is discussed. Fermat's and Euler's Theorems are explained. Then the field of quotients of an integral domain should be discussed with proof. Also rings of polynomials are introduced along with factorization of polynomials over a Field are to be given in detail. (**Exclude the section "our basic goal" in section 22 and exclude the proof of Theorem 23.11 and Theorem 23.15 in section 23**).

The topics to be discussed in this module can be found in section 18, 19, 20, 21, 22, 23 of text [1] below. Also, discuss the problems 38,48,49 in section 18; 23,24 in section 19

Module Specific Outcomes Upon Completion of this Module, students will be able to

- understand the algebraic structures Rings and Fields.
- analyse the structures containing zero divisors.
- construct field of quotients of an integral domain.
- develop the idea of factorization of polynomials.

Module II (18 Hours)

This module starts with defining Homomorphisms of rings. Then properties of ring homomorphisms are introduced. Then move on to the concept of a factor ring. All examples should be discussed (**Exclude the section "a preview of our basic goal in section 27"**). Then, proceed to define the notion of Prime and Maximal Ideals. Examples and all the Theorems must be explained in detail.

The topics to be discussed in this module can be found in section 26 and 27 of text [1] below.

Module Specific Outcomes Upon Completion of this Module, students will be able to

- examine the structure preserving maps in various structures.
- construct factor ring.
- develop the idea of prime and maximal ideals.
- understand the relation beten prime and maximal ideals with integral domain and field.

Module III (18 Hours)

The idea of unique factorization domains is introduced in this module. Ascending chain condition for a PID should be explained. Also prove Fundamental Theorem of Arithmetic and Gauss's lemma. Then move on to the concept of Euclidean domains and arithmetic in Euclidean Domains.

The topics to be discussed in this module can be found in section 45 and 46 of text [1] below.

Module Specific Outcomes Upon Completion of this Module, students will be able to

- recognize the idea of unique factorization domains.
- develop the idea of fundamental Theorem of arithmetic.
- identify the prime elements in a general abstract structure and decomposing any element into product of primes.
- examine the Euclidean domains.

Text

Text 1 John B. Fraleigh, *A First Course in Abstract Algebra*, Seventh Edition, Pearson Education, Inc.,2003.

References

Ref. 1 Joseph A. Gallian, *Contemporary Abstract Algebra*, Eighth Edition, BROOKS/COLE CENGAGE Learning.

Ref. 2 Vijay K. Khanna and S. K. Bhambri, *A Course in Abstract Algebra*, Fifth Edition, Vikas Publications.

Ref. 3 I. N. Herstein, *Topics in Algebra*, Second Edition, Wiley, 2006.

Semester VI

Integral Equations

Code: MM 1644 Instructional hours per week: 4

No. of credits: 3

Course Outcomes:

CO1 Categorise and solve different integral equations using various techniques.

CO2 Enable to apply Laplace Transforms to various industry related and applied problems.

CO3 Analyse the properties of certian functions using Fourier series.

Module I - Laplace Transforms (38 Hours)

Laplace Transform. Linearity. First Shifting Theorem (s-Shifting), s-Shifting: Replacing s by $s-a$ in the Transform, Existence and Uniqueness of Laplace Transforms.
Transforms of Derivatives and Integrals. ODEs: Laplace Transform of derivatives, Laplace Transform of the Integral of a function, Differential Equations, Initial Value Problem
Unit Step Function (Heaviside Function), Second Shifting Theorem (t-Shifting) Time Shifting (t-Shifting): Unit Step Function (Heaviside Function) $u(t-a)$, Time shifting (Replacing t by $t-a$ in $f(t)$)
Short Impulses. Diracs Delta Function. Partial Fractions, Convolution, Integral Equations, Application to Nonhomogeneous Linear ODEs
Differentiation and Integration of Transforms, ODEs with Variable Coefficients:
Differentiation of Transforms, Integration of Transforms, Special Linear ODEs with Variable Coefficients Systems of ODEs.

The topics to be discussed in this module can be found in sections 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7 of text Book.

Module Specific Outcomes

- Able to understand Laplace transforms
- Able to evaluate Laplace transform of functions using various methods
- Enable the students to solve linear higher order differential equations, system of differential equations using Laplace Transform

Module II - Fourier Series (34 Hours)

Fourier Series: Basic Examples, Derivation of the Euler Formulas, Convergence and Sum of a Fourier Series.
Arbitrary Period. Even and Odd Functions. Half-Range Expansions: From Period 2π to any Period $p = 2l$; Simplifications: Even and Odd Functions, Half Range Expansions
Fourier Integral: Definition From Fourier Series to Fourier Integral, Applications of Fourier Integrals, Fourier Cosine Integral and Fourier Sine Integral.
Fourier Cosine and Sine Transforms: Fourier Cosine Transform, Fourier Sine Transform, Linearity, Transforms of Derivatives.
Fourier Transform, Discrete and Fast Fourier Transform: Complex Form of the Fourier Integral, Fourier Transform and Its Inverse, Linearity. Fourier Transform of Derivatives, Convolution.

[The topics to be discussed in this module can be found in Sections 11.1, 11.2, 11.7, 11.8, 11.9 (Excluding Physical Interpretation: Spectrum and Discrete Fourier Transform (DFT),Fast Fourier Transform (FFT)) of the text.]

Module Specific Outcomes

- Understand the concept of Fourier Series in to the infinite series containing constants, sine and cosine functions
- Able to find Cosine and Sine series expansions for given functions
- Able to calculate Fourier transform of a function
- Able to understand the Fourier integral generated from Fourier series

Text

Text 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, Wiley Publishers, 10^{th} Edition, 2018

References

Ref. 1 A. N. Srivastava, Mohammad Ahmad, Sreevastava, *Integral Transforms And Fourier Series*, Narosa Publications, 2012

Ref. 2 M Greenberg, *Advanced Engineering Mathematics*, Prentice Hall, 2^{nd} Edition, 1998.

Ref. 3 Peter V. O Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

Ref. 4 Veerarajan, *Differential Equations and Laplace Transforms*, Yes Dee Publications, 2020.

Semester VI

Graph Theory (Elective)

Code: MM 1661.1 Instructional hours per week: 3

No. of credits: 2

Course Overview: Graph theory is a branch of discrete mathematics dealing with the connection between objects. This course has been designed to build awareness of the fundamental concepts of Graph Theory and to develop the problem-solving ability and mathematical maturity in this area.

Course Outcomes:

CO1 To define and understand the fundamental concepts of graph theory

CO2 To apply the concepts and theorems that are treated in the course for problem-solving and proofs

CO3 To write combinatorial proofs, including those using basic graph theory proof techniques such as minimal counterexamples, double counting, and Mathematical induction.

Module I (27 Hours)

Basics: Definitions and examples of graphs, Isomorphism, connectedness, adjacency and degrees, subgraphs, complement of a simple graph, examples, and matrix representations. Standard classes of graphs: Null graphs, complete graphs, paths and cycles, wheels, regular graphs, Platonic graphs, bipartite graphs, and Cubes. Recreational puzzles: The eight circles problem, Six people at a party, and The four cube problem.

Paths and cycles: Connectivity - walks, paths and trials, disconnecting set, cutsets, brides, edge connectivity, and vertex connectivity. Eulerian graphs, Hamiltonian graphs.

The topics to be discussed in this module can be found in Chapter 1(Sections 1.1, 1.2 and 1.4), and Chapter 2(Sections 2.1, 2.2 and 2.3) of the prescribed text below.
In Chapter 2(Section 2.1), Theorem 2.4, Theorem 2.5, and the subsections digraphs and infinite graphs NEED NOT be discussed.
In Chapter 2(Section 2.2), the subsections Eulerian digraphs and infinite Eulerian graphs NEED NOT be discussed)
In Chapter 2(Section 2.3), the subsection Hamiltonian digraphs NEED NOT be discussed.

Module Specific Outcomes

- To explain preliminary concepts of graphs
- To explain standard classes of graphs
- To represent graphs using adjacency and incident matrices
- To identify Euler and Hamiltonian graphs

Module II (27 Hours)

Trees: properties of trees. Planarity: planar graphs, Kuratowski's theorems (proofs NEED NOT be discussed), Euler's formula.

Colouring graphs: colouring vertices, Brook's theorem (proof of Brook's theorem NEED NOT be discussed), Colouring planar graphs-six-colour theorem, five-colour theorem, and a brief discussion about the four-colour problem.

The topics to be discussed in this module can be found in Chapter 3(Section 3.1), Chapter 4(Sections 4.1 and 4.2), and Chapter 5(Section 5.1) of the Prescribed text below.
In Chapter 4(Section 4.1), proof of Theorem 4.2, proof of Theorem 4.3, and the subsection infinite planar graphs NEED NOT be discussed.
In Chapter 5(Section 5.1), proof of Theorem 5.2 NEED NOT be discussed.

Module Specific Outcomes

- To define the properties of bipartite graphs, particularly in trees.
- To understand the concept of planar graphs and graph coloring.
- To explain Kuratowski's theorems.
- To Proves Euler formula.

Text

Text 1 Robin J. Wilson, *Introduction to Graph Theory*, Pearson Education Asia, 5$^{\text{th}}$ Edition, 2010.

References

Ref. 1 Gary Chartrand and Ping Zhang, *Introduction to Graph Theory*, New Delhi, New York: Tata McGraw-Hill Pub. Co., 2006.

Ref. 2 Douglas B. West, *Introduction to Graph Theory*, 2nd Edition, Prentice Hall, New Jersey, 2011

Ref. 3 R. Balakrishnan, K. Ranganathan, *A Text book of Graph Theory*, Second Edition, Springer, 2012.

Semester VI

Fractal Geometry (Elective)

Code: MM 1661.2 Instructional hours per week: 3

No. of Credits 2

Fractal Geometry is a mathematical examination of the concepts of self similarity, fractals, chaos and their applications to the modeling of natural phenomena.

Course Outcomes: After the completion of the course the students will be able to

CO1 Enjoy the natural beauty of the world with new way of looking at with the mathematical ideas of fractal geometry and chaos theory.

CO2 Construct and analyse a wide range of fractals.

Module I (27 Hours)

Mathematical Background [Chapter 1, Sections 1.1-1.3]
Basic set theory, Functions and limits, Measures and mass distributions
Hausdorff Measures and Dimension [Chapter 2, Sections 2.1-2.3]
Hausdorff measure, Scaling property, Hausdorff dimension, Fundamental property, Calculation of Hausdorff dimension, Examples
Alternate definitions of dimension [Chapter 3, Sections 3.1-3.2]
Box-counting dimensions, dimension of Cantor set, Properties and problems of boxcounting dimension.
Techniques for calculating dimensions [Chapter 4, Section 4.1]
Basic methods, Uniform Cantor sets, Covering lemma

Module Specific Outcomes

- Students acquired the knowledge of sets, functions, monotonicity, stability, countable stability, geometric invariance, Lipschitz invariance etc
- They could identify measure and mass distribution
- They could generalize Hausdorff measures from the familiar ideas of length, area, volume etc.
- They could identify Hausdorff dimension as the critical value at which there is a jump from infinity to zero and Hausdorff dimension is invariant under bi-Lipschitz transformations.

- Students acquired the skill of heuristic calculation of Hausdorff dimension

- They could identify the five ways of finding the box dimension of a bounded set F

- They could apply the knowledge in the construction of uniform cantor set.

Module II (27 Hours)

Iterated Function Systems [Chapter 9, Sections 9.1-9.3]
Contraction, Contracting similarity, Iterated function system, Dimensions of self-similar sets, Sierpiński triangle, Modified von Koch curve, Some variations
Graphs of Functions [Chapter 11, Section 11.1]
Dimensions of graphs, Weierstrass function, Dimension of Self-affine curves
Dynamical Systems [Chapter 13, Sections 13.1-13.2]
Repellers and iterated function systems, The logistic map
Iteration of Complex Functions [Chapter 14, Sections 14.1-14.3]
General theory of Julia sets, Montel's theorem (without proof), Quadratic functions-the Mandelbrot set, Julia sets of quadratic functions

Module Specific Outcomes

- Students acquired the knowledge of IFS, self-similar sets, Sierpiński triangle, von Koch curve , dimension of graphs, discrete dynamical system, Julia sets etc.

- They could identify Stages in the construction of a self-affine curve F, logistic maps, attractor, repeller etc.

- They could identify that the Julia set $J(f)$ is forward and backward invariant under f, Also $J(f)$ is a perfect set.

- They could identify that $J(f) = J(f^p)$ for every positive integer p.

- They could identify normal families of analytic functions, Montel's theorem and attractive fixed point of a polynomial

- They could characterize J as the boundary of any basin of attraction

- Students might have the drawing skill of Julia sets and the Mandelbrot sets on computers

Text

Text 1 Kenneth Falconer, *Fractal Geometry*, Second Edition, Wiley, 2003, ISBN 0-470-84862-6

References

Ref. 1 Michael F. Barnsley, *Fractals Everywhere*, 2^{nd} Edition, Springer

Ref. 2 Nigel Lesmoir-Gordon, *Introducing Fractals, A Graphic Guide*, Published by Icon Books Ltd, London.

Semester VI

Numerical Methods (Elective)

Code: MM 1661.3 Instructional hours per week: 3

No. of Credits 2

Course Outcomes: After the completion of the course the students will be able to

CO1 Calculate errors in numerical calculations

CO2 Find numerical solutions of Algebraic and Transcendental Equations

CO3 Apply numerical methods to find differentiation and integration

Module I - Errors in Numerical Calculations and Solution of Algebraic and Transcendental Equations (18 Hours)

Computer and Numerical Software, computer languages, software packages, Mathematical preliminaries, Errors and their computations, general error formula, error in series approximation
Bisection method, method of false position, iteration method, Newton-Raphson Method, Ramanujan's method, Secant Method, Muller's method

The topics to be discussed in this module can be found in Chapter 1 sections 1.1 to 1.5, Chapter 2 sections 2.1 to 2.8 of text [1] below. (There will be no questions from section 1.1 for examination).

Module Specific Outcomes

- Understand the concept of errors
- Compute roots of algebraic and transcendental equations

Module II – Interpolation (18 Hours)

The following are the main topics in this module:
Errors in polynomial interpolation, Finite differences, detection of errors by difference table, differences of a polynomial, Newton's formulae for interpolation

The topics to be discussed in this module can be found in Chapter 3 section 3.1 to 3.6.

Module Specific Outcomes

- Computing finite differences
- Describing polynomial interpolation

Module IV – Numerical Differentiation and Integration (18 Hours)

The following are the main topics in this module:
Numerical differentiation-Errors in numerical differentiation, differentiation formulae with function values, maximum and minimum values of a tabulated function, Numerical integration-Trapezoidal rule, Simpson's 1/3-rule, Simpson's 1/8-rule, Boole's and Weddle's rule, Romberg integration, Newton-Cotes formulae, Euler-Maclaurin formula.

The topics to be discussed in this module can be found in Chapter 6 section 6.1 to 6.5. Subsections 6.2.2, 6.4.4, 6.4.5, 6.4.6 may be omitted.

Module Specific Outcomes

- Understanding numerical differentiation and integration
- Determining numerical differentiation and integration

Text

Text 1 S. S. Sastry, *Introductory Methods of Numerical Analysis*, Fifth Edition, PHI Learning Private Limited, 2012

References

Ref. 1 Richard L. Burden, J. Douglas Faires *Numerical Analysis*, 9th Edition, Cengage Learning.

Ref. 2 A. C. Faul, A Concise *Introduction to Numerical Analysis*, CRC Press.

Ref. 3 Timo Heister, Leo G. Rebholz, Fei Xue, *Numerical Analysis An Introduction*, De Gruyter, 2019

Ref. 4 Timothy Sauer, *Numerical Analysis*, Third Edition, Perason Education, 2018

Semester VI

Programming with Python

Code: MM 1645 Laboratory hours per week: 3

No. of credits: 4

Course Outcomes: After the completion of the course the student will be:

CO1 aquainted with writing and executing programmes in Python

CO2 able to use Python for basic math computing and visualising data.

Module I - Basics of Python (10 Hours)

Installing Python - Basic Interactive Mode - IDLE - Quick Python Review

(Chapter 2,3 of Text 1)

Module Specific Outcome

- Write and execute a simple Python programme.

Module II - The Essentials (18 Hours)

Absolute Basics - Lists, tuples and sets - Strings - Control Flow - Functions - Reading and writing files

(Chapter 4,5 (except 5.6, 5.8),6 (except 6.5-6.9),8, 9.1-9.5 (except 9.3) and 13.1-13.4 of Text 1) **Module Specific Outcomes**

- Learn to use arrays, functions, to control fow of execution.
- Read and write files

Module III - Working with numbers (16 Hours)

Basic Mathematical Operations - Working with different kinds of numbers - Getting user input - Math Programmes - The Programming challenges mentioned in Chapter 1 of Text 2

(Chapter 1 of Text 2)

Module Specific Outcome

- Learn to write simple math related programmes such as for finding factors, finding roots of a quadratic equation etc.

Module IV - Visualising Data with Graphs (10 Hours)

Working with Lists and Tuples - Creating Graphs with Matplotlib

(Chapter 2 of Text 2 except "Plotting with Formula")

Module Specific Outcome

- Learn to plot graphs and save them as image files

Note: A record should be maintained with at least 10 programmes, illustrating both their source code and output. This record should be submitted at the time of the practical examination.

Internal Evaluation: Of the total 20 marks earmarked for internal evaluation, the record maintained for LaTeX (in Semester V) and the record maintained for Python should be awarded a maximum of 10 marks each.

Texts

Text 1 Naomi Ceder, *The Quick Python Book*, Manning, 2018

Text 2 Amit Saha, *Doing Math with Python*, No Starch Press, 2015

References

Ref. 1 Kenneth A Lambert, *Fundamentals of Python, First Programs*, 2nd Edition, Cengage, 2019

Ref. 2 E Balagurusamy, *Introduction to computing and problem solving using Python*, Mc Graw Hill Education, 2017.

Ref. 3 https://www.python.org/

Semester VI

Project

Code: MM 1646 Instructional hours per week: 2

No. of Credits 4

Project Preparation- From selecting the topic to presenting the final report

Course Outcomes: After the completion of the course the students will be able to

CO1 Understand how mathematical research is being carried out by getting exposed to various proof techniques

CO2 Develop the skill to use modern techniques that are helpful in gathering information from the web

CO3 Develop the skills for interpreting the theories in different areas of the subject

CO4 Develop the ability to defend the scientific assertions and findings

CO5 Develop scientific temperament and perseverance

To complete the undergraduate programme, the students should undertake a project and prepare and submit a project report on a topic of their choice in the subject Mathematics or allied subjects. The work on the project should start in the beginning of the sixth semester. The project report should be submitted towards the end of the sixth semester itself and there will be a vivavoce examination based on the project. This course is introduced for making the students understand various concepts behind undertaking such a project and preparing the final report. Towards the end of this course the students should be able to choose and prepare topics in their own and they should understand the layout of a project report.

To quickly get into the business, the first chapter of text [1] may be completely discussed. Apart from that, for detailed information, the other chapters in this book may be used in association with the other references given below. The main topics to discuss in this course are the following:

Quick overview: The structure of Dissertation, creating a plan for the Dissertation, planning the results section, planning the introduction, planning and writing the abstract, composing the title, figures, tables and appendices, references, making good presentations, handling resources like notebooks, library, computers etc, preparing an interim report.

Topics in detail: Planning and Writing the Introduction, Planning and Writing the Results, Figures and Tables, Planning and Writing the discussion, Planning and Writing the References, Deciding On a Title and Planning and Writing the Other Bits, Proofreading, Printing, Binding and Submission, Oral Examinations, Preparing for Viva, Taking the Dissertation to the viva.

Layout: Fonts and Line Spacing, Margins, Headers and footers, Alignment of Text, Titles and Headings, Separating Sections and Chapters

Text

Text 1 Daniel Holtom, Elizabeth Fisher: *Enjoy Writing Your Science Thesis or Dissertation - A step by step guide to planning and writing dissertations and theses for undergraduate And graduate science students*, Imperial College Press

References

Ref. 1 Kathleen McMillan, Jonathan Weyers, *How to write Dissertations and Project Reports*, Pearson Education Limited

Ref. 2 Peg Boyle Single, *Demystifying dissertation writing: a streamlined process from choice Of topic to final text*, Stylus Publishing Virginia

First Degree Programme in

Computer Applications (BCA)

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

Sem	Course Code	Course Title	Instructional Hours per Week	Credit	Maximum Marks		
					CA	ESA	Total
I	MM 1131.9	Mathematics I	4	3	20	80	100
II	MM 1231.9	Mathematics II	4	3	20	80	100

PROGRAMME SPECIFIC OUTCOMES (PSO) FOR COMPLEMENTARY COURSE IN MATHEMATICS FOR FIRST DEGREE PROGRAMME IN COMPUTER APPLICATIONS-BCA

PSO1 To become familiar with modern mathematics and provide strong foundation in mathematics

PSO2 Recognize and appreciate the connections between theories and applications

PSO3 To acquire knowledge about certain mathematical concepts and techniques and their applications in computer software

PSO4 To apply Mathematics to analyze and develop computer programmes in the areas related to system software web designs and networking for efficient design

Semester I

Mathematics I

Code: MM1131.9 Instructional hours per week: 4

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 Recall basic differentiation techniques, concepts of prime numbers and general concepts of differential equations. (Knowledge level).

CO2 Discuss hyperbolic and inverse hyperbolic function, Mean value theorem and Rolle's theorem. (Understanding Level)

CO3 Compute solution of differential equations, real part, imaginary part, polar form,exponentand log of complex numbers. (Applying Level)

CO4 Explain unique factorization theorem, Euclidean algorithm, congruence, Fermat's theorem and Wilson's theorem. (Analysing Level)

Module I (18 Hours)

Review of basic differentiation, Differentiation of hyperbolic functions, derivatives of hyperbolic functions, inverse hyperbolic functions logarithmic differentiation, implicit differentiation, Mean value theorem, Rolle's theorem.

Sections 2.3, 2.4, 2.5, 2.6, 2.7 of Chapter 2, 3.4 and 3.8 of Chapter 3 and 6.2 [exclude integration results] and 6.8 of Chapter 6 of Text 1.

Module Specific Outcome

- A student should be able to find derivate of given function using many techniques. Also got a knowledge mean value theorem and Rolle's theorem

Module II (18 Hours)

Differential equations, General Concepts, Formulation and solution of differential equations, first order (variable separable, homogeneous, exact) and second order with constant coefficients (complementary solution, particular solution).

Sections 1.1, 1.3, 1.4 and 1.5 of Chapter 1 and Section 2.1 and 2.2 of Chapter 2 of Text 2.

Module Specific Outcome

- A student should be able to solve first and second order differential equation

Module III (18 Hours)

Theory of Numbers, prime numbers, Unique factorization theorem, Euclidean algorithm, congruences, Fermat's theorem, Wilson's theorem. [Theorems without proof]

Sections 2.5 of Chapter 2, Sections 3.1 and 3.2, Sections 4.1 and 4.2 and Sections 7.1 and 7.2 (Avoid Optional sections in text) of Text 3.

Module Specific Outcome

- A student should be able to understand various concepts of numbers like GCD, congruence and various theorems

Module IV (18 Hours)

Complex Numbers, Separation into real and imaginary parts, Polar form of complex numbers, exponential and log of complex numbers

Sections 13.1, 13.2, 13.5 and 13.7 of Chapter 13 of Text 2.

Module Specific Outcome

- A student should be able to find real and imaginary parts, Polar form of complex numbers, exponential and log of complex numbers.

Texts

Text 1 H Anton, I Bivens, S Davis. *Calculus*, 10^{th} Edition, John Wiley & Sons.

Text 2 Erwin Kreyzig, *Advanced Engineering Mathematics*, 9^{th} edition, New Age International Pvt Ltd.

Text 3 Thomas Koshy, *Elementary Number Theory with Applications*, 2^{nd} Edition, Academic Press.

References

Ref. 1 Shanthi Narayan, *Differential Calculus*, S Chand & Company Zafar Ahsan, Differential Equations and their applications.

Ref. 2 Rudra Pratap, *Getting Started with MATLAB*, Oxford University Press.

Semester II

Mathematics II

Code: MM1231.9 Instructional hours per week: 4

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 Recall set theory concepts, set operations, relations and its operations, equivalence relations and partitions, algebra and functions. (Remembering level)

CO2 Explain formal proofs, methods of proofs (proofs by contradiction, false proof and induction), logical equivalence, DeMorgan's law, tautologies, Implications, arguments, fallacies, communication model and error corrections. (Understanding Level)

CO3 Illustrate characteristic functions, Warshal's algorithm, recursion, group, ring, polish expressions and hamming codes. (Understanding Level)

CO4 AnalyzeNormal forms in prepositional logic, resolution, partial orders and ordered sets. (Analysing Level)

Module I (18 Hours)

Proof Methods, Logic: Formal proofs, Propositional reasoning, Proofs by contradiction, False Proofs, Proofs by Induction, Symbolic Logic: Boolean expressions, Logical Equivalence.

Introduction chapter from page 1 to 11 and Sections 1.2, 1.3, 1.4, 1.5 and 1.6 of Chapter 1 of the text.

Module Specific Outcome

- A student should be able to understand proof methods and symbolic logic.

Module II (18 Hours)

DeMorgan's Law, tautologies, Implications, Arguments, Fallacies, Normal forms in prepositional logic, Resolution, Review of Set theory concepts, set operations (avoid proofs), characteristic functions.

Sections 1.7, 1.9 to 1.19, 1.30, 1.31 and 1.33 of Chapter 1 and Sections 2.1, 2.3 and 2.4 of Chapter 2 of the text.

Module Specific Outcome

- A student should be able to understand DeMorgan's Law, tautologies, Implications, Arguments, Fallacies, Normal forms in prepositional logic, Resolution, Review of Set theory concepts, set operations and characteristic functions.

Module III (18 Hours)

Relations: operations on relations, equivalence relations and partitions, partial orders, ordered sets, Warshal's algorithm, Functions. (Avoid computer programs).

Sections 3.1 to 3.7 of Chapter 3 and Section 4.1 of Chapter 4 of the text.

Module Specific Outcome

- A student should be able to understand operations on relations, equivalence relations and partitions, partial orders, ordered sets, Warshal's algorithm and Functions

Module IV (18 Hours)

Algebraic Structures: Algebra, DeMorgan's Law, Group, Subgroups examples and simple properties, Communication Model and error corrections, Hamming Codes.(Avoid computer programs).

Sections 5.1, 5.2, 5.3, 5.6 and 5.7 of the text.

Module Specific Outcome

- A student should be able to understand Algebraic Structures, DeMorgan's Law, Group, Subgroups examples and simple properties, Communication Model and error corrections, Hamming Codes

Text

Text 1 Rajendra Akerkar, Rupali Akerkar, *Discrete Mathematics*, Pearson Education

References

Ref. 1 R M Somasundaram, *Discrete Mathematical structures*, PHI Learning Pvt. Ltd.

Ref. 2 Calvin C. Clawson, *Mathematical Mysteries, The beauty and magic of Numbers*, Viva Books Pvt Ltd.

Ref. 3 Rudra Pratap, *Getting Started with MATLAB*, Oxford University Press.

First Degree Programme in

Chemistry and Industrial Chemistry

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

Sem	Course Code	Course Title	Instructional Hours per Week	Credit	Maximum Marks		
					CA	ESA	Total
I	MM 1131.7	Differential calculus of one variable and complex numbers	5	3	20	80	100
II	MM 1231.7	Integral calculus of one variable	5	3	20	80	100
III	MM 1331.7	Differential equations, Linear equations, Fourier series and Theory of equations	5	4	20	80	100
IV	MM 1431.7	Abstract algebra, Vector algebra, Vector calculus and Laplace Transforms	5	4	20	80	100

PROGRAMME SPECIFIC OUTCOMES (PSO) FOR COMPLEMENTARY COURSE IN MATHEMATICS FOR FIRST DEGREE PROGRAMME IN CHEMISTRY AND INDUSTRIAL CHEMISTRY

PSO1 To provide strong foundation in Mathematics

PSO2 To acquaint students with the essential mathematical methods to analyse functions

PSO3 To make students capable of solving polynomial equations and differential equations

PSO4 To enable students to apply the concepts such as differentiation and integration

Semester I

Mathematics I
(Differential Calculus of One variable and Complex Numbers)

Code: MM 1131.7 Instructional hours per week: 5

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 Compute the limits and derivatives.

CO2 Explain the concept rate of change.

CO3 Analyse function behavior.

CO4 Understand basic concepts of complex numbers.

Module I - Limits and continuity (24 Hours)

Definition of limits, One sided limits, two sided limits and infinite limits, computing limits, limits of polynomials and rational functions, limits involving radicals, limits of piecewise defined functions, limits at infinity. Continuity - Definition, continuity of polynomials and rational functions, continuity of compositions and continuity of Trigonometric functions.

Sections: 1.1, 1.2, 1.3, 1.5.1 to 1.5.6 and 1.6 of chapter 1 of text [1]

Module Specific Outcome

- A student should be able to apply limits to a wide variety of functions including piece wise, polynomial, rational and trigonometric. Also got a knowledge on continuity.

Module II - Differential Calculus of one variable (24 Hours)

Tangent lines, velocity, slopes and rates of change,rates of change in applications, Definition of the derivative function, computing instantaneous velocity, differentiability, relationship between differentiability and continuity, derivatives at the end points of an interval, other derivative notations, Techniques of differentiation, higher derivatives, product and quotient rule, derivatives of trigonometric functions, chain rule and implicit differentiation.

Sections : 2.1 to 2.7 of chapter 2 of text [1]

Module Specific Outcome

- A student should be able to compute derivatives of algebraic and trigonometric functions and calculate rates of changes related to day to day life.

Module III - Applications of Derivatives (24 Hours)

Increase and decrease functions, concavity, absolute maxima and minima, Rolle's theorem, Mean value theorem, L-Hospital's rule for evaluating limits in case of indeterminate forms.

Sections : 3.1, 3.2, 3.4, 3.5 and 3.8 of chapter 3 and 6.5 of chapter 6 in text [1].

Module Specific Outcome

- A student should be able to understand the various behavior of functions by applying derivative tests and evaluate the limits of indeterminate forms.

Module IV - Complex numbers (18 Hours)

Complex numbers, geometric representation of imaginary numbers, geometric representation of $z_1 + z_2$, De-Moivre's theorem (without proof), roots of a complex number, complex function, exponential function of a complex variable..

Sections : 19.1 to 19.8 of chapter 19 of text [2]

Module Specific Outcome

- A student can understand the basic concepts of Complex numbers, complex functions and evaluate the roots of a complex number.

Texts

Text 1 Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10^{th} Edition, John Wiley and Sons.

Text 2 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43^{rd} Edition, Khanna Publishers.

References

Ref. 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} Edition, Wiley-India.

Ref. 2 K F Riley, M P Hobson, S J Bence, *Mathematical methods for Physics and Engineering* 3^{rd} *Edition*, Cambridge University Press.

Semester II

Mathematics II
(Integral Calculus of One variable)

Code: MM 1231.7 Instructional hours per week: 5

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 Explain the relationship between area and integral.

CO2 Compute integrals.

CO3 Compute area and volume using integration.

CO4 Understand basic concepts of co ordinate geometry and some special functions.

Module I - Integral calculus of one variable (24 Hours)

Area problem, the rectangle method for finding areas, Indefinite integral (integration from the view point of differential equations, slope fields, integral curves are excluded) integration by substitution, The definite integral (section 4.5 up to theorem 4.5.6), Fundamental theorem of Calculus, relationship between definite and indefinite integrals, Mean value theorem for integrals (without proof), Evaluating definite integrals by substitution.

Sections 4.1, 4.2, 4.3, 4.5, 4.6 and 4.9 of chapter 4 of text [1].

Module Specific Outcome

- A student should be able to get the thorough knowledge about integration.

Module II - Applications of Integration (24 Hours)

Area between two curves, Volumes by slicing disks and washers, volume by cylindrical shells, length of a plane curve, Area of surface of revolution.

Sections : 5.1 to 5.5 of chapter 5 of text [1].

Module Specific Outcome

- A student should be able to apply the concept of integration in a real life situation.

Module III - Foundations of coordinate geometry (24 Hours)

Parametric equations of a curve, orientation of a curve, expressing ordinary functions parametrically, tangent lines to parametric curves, arc length of parametric curves, Polar coordinate systems, relationship between polar and rectangular coordinate systems, graphs in polar coordinate system, symmetry test in polar coordinate system, tangent lines to polar curves, arc length of a polar curve, area in polar coordinates.

Sections: 10.1, 10.2 and 10.3 of chapter 10 of text [1].

Module Specific Outcome

- A student should be able to know the basics of coordinate geometry.

Module IV - Special Functions (18 Hours)

Factorial function, Definition of Γ function, recursion relation, Γ function of negative numbers, some important formulas involving gamma functions, β functions, β functions in terms of Γ functions.

Sections 11.1 to 11.7 of text [2].

Module Specific Outcome

- A student should be able to know about some special functions such as Γ and β.

Texts

Text 1 Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10$^{\text{th}}$ Edition, John Wiley and Sons.

Text 2 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3$^{\text{rd}}$ Edition, Wiley.

References

Ref. 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10$^{\text{th}}$ Edition, Wiley-India.

Ref. 2 K F Riley, M P Hobson, S J Bence, *Mathematical methods for Physics and Engineering*, 3rd Edition, Cambridge University Press.

Ref. 3 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43rd Edition, Khanna Publishers.

Semester III

Mathematics III
(Differential Equations, Linear Equations, Fourier Series and Theory of Equations)

Code: MM 1331.7 Instructional hours per week: 5

No. of Credits 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Describe a first order differential equation and solve it.

CO2 Analyse the consistency of system of linear equations and solve it.

CO3 Understand linear transformation and eigen values.

CO4 Write the Fourier series of a periodic function.

CO5 Understand the nature of roots fo polynomials and apply find approximate solutions.

Module I - First Order Ordinary Differential Equations (24 Hours)

Differential Equations of first order - Definitions, solution of a differential equations, equations of the first order and first degree variable separable, homogeneous equations, equations reducible to homogenous form, linear equations, Bernoulli's equations, exact differential equations, equations reducible to exact equations, equations of the first order and higher degree, Clairaut's equation.

Chapter11 of text [1].

Module Specific Outcome

- A student should be able to understand, analyse and apply first order ordinary differential equations.

Module II - System of linear Equations (24 Hours)

Introduction to determinants and matrices, rank of a matrix, solution of linear system of equations (exclude matrix inversion method), consistency of linear system of equations, linear transformations, vectors, eigenvalues, properties of eigen values (statement only), Cayley Hamilton theorem (statement only).

Sections : 2.1, 2.2, 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14 and 2.15 of Chapter 2 of text[1]

Module Specific Outcome

- A student should be able to understand the concept of matrices and apply it to find the rank, solution and consistency of linear system of equations and the properties of eigen values.

Module III - Fourier Series (24 Hours)

Periodic functions, trigonometric series, Fourier series, Fourier coefficients, Euler formulas, periodic rectangular wave, derivation of Euler formulas, Arbitrary period, even and odd functions, half range expansions.

Sections : 11.1 and 11.2 of chapter 11 of text [2].

Module Specific Outcome

- A student should be able to know about the Fourier series and to solve related problems.

Module IV - Theory of Equations (18 Hours)

Fundamental theorem of Algebra(with out proof), relations between roots and coefficients of a polynomial, Reciprocal Equation, Descartes' rule of signs, finding approximate roots by bisection method and Newton - Raphson method. (Exclude symmetric functions of the roots, Sums of powers of the roots and Transformations of equations)

These topics can be found in text [3].

Module Specific Outcome

- A student should be able to understand nature of roots of polynomials, relation between roots and coefficients and applying methods to find approximate roots.

Texts

Text 1 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43rd Edition, Khanna Publishers.

Text 2 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th Edition, Wiley-India.

Text 3 Barnard and Child, *Higher Algebra*, Mac Millan.

References

Ref. 1 Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10^{th} Edition, John Wiley and Sons.

Ref. 2 Peter V O Neil, *Advanced Engineering Mathematics*, Thompson publications, 2007.

Ref. 3 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3^{rd} Edition, Wiley.

Semester IV

Mathematics IV
(Abstract Agebra, Vector Algebra, Vector Calculus and Laplace Transforms)

Code: MM 1431.7 Instructional hours per week: 5

No. of Credits 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Understand basics of group theory with examples and describe elementary properties of groups.

CO2 Understand and apply basic operations among vectors.

CO3 Apply vector operators on scalar and vector point functions.

CO4 Apply Laplace transform on different functions.

Module I - Abstract Algebra (24 Hours)

Group- definition and examples, elementary properties, finite groups and subgroups, cyclic groups, elementary properties, result on order of elements.

Sections : 2, 4, 5 and 6 of text [2].

Module Specific Outcome

- A student should be able to understand concepts of group theory with examples.

Module II - Vector Algebra (18 Hours)

Vectors, section formula,products of two vectors, physical applications, scalar triple product, vector product of three vectors.

Sections: 3.1 to 3.10, text [1]

Module Specific Outcome

- A student should be able to understand analyse and apply various concepts of Vector Algebra.

Module III - Vector Calculus (24 Hours)

Differentiation of Vectors,curves in space, velocity and acceleration, scalar and vector point functions, del applied to scalar point functions - gradient and vector point functions, physical interpretation of divergence, del applied twice to point functions,product of point functions, line integral.

Sections 8.1 to 8.11, text [1].

Module Specific Outcome

- A student should be able to understand analyse and apply various concepts of vector calculus.

Module IV - Laplace Transforms (24 Hours)

Definition, transforms of elementary functions, properties of Laplace transforms, transforms of periodic functions, transforms of special functions, transforms of derivatives and integrals, multiplication by t^n, division by t, Evaluation of integrals by Laplace transforms.

Sections : 21.1 and 21.11 of chapter 21 of text [1].

Module Specific Outcome

- A student should be able to know about the Laplace transforms and to solve related problems.

Texts

Text 1 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43^{rd} Edition, Khanna Publishers.

Text 2 J B Fraleigh, *A First Course in Abstract Algebra*, 7^{th}Edition, Pearson Education, INC.

References

Ref. 1 Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10^{th} Edition, John Wiley and Sons.

Ref. 2 Joseph Gallian, *Contemporary Abstract Algebra*, 8^{th} Edition.

Ref. 3 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3^{rd} Edition, Wiley.

First Degree Programme in

Physics and Computer Applications

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

Sem	Course Code	Course Title	Instructional Hours per Week	Credit	Maximum Marks		
					CA	ESA	Total
I	MM 1131.6	Mathematics I - Differential calculus of one variable and Special functions	5	4	20	80	100
II	MM 1231.6	Mathematics II - Integral calculus of one variable, Coordinate geometry and Complex numbers	5	4	20	80	100
III	MM 1331.6	Mathematics III - Differential equations, Linear equations, Abstract algebra and Laplace transforms	5	4	20	80	100
IV	MM 1431.6	Mathematics IV - Fourier series, Vector algebra, Vector calculus and Theory of equations	5	4	20	80	100

PROGRAMME SPECIFIC OUTCOMES (PSO) FOR COMPLEMENTARY COURSE IN MATHEMATICS FOR FIRST DEGREE PROGRAMME IN PHYSICS AND COMPUTER APPLICATIONS

PSO1 To acquire basic knowledge in functional areas of Mathematics and apply in the relevant field of learning

PSO2 To develop critical thinking, creative thinking and self confidence for the eventful success in career

PSO3 To recognize the importance and value of mathematical thinking and approach to problem solving

PSO4 To acquire relevant knowledge and skills in Mathematics appropriate to professional activities

PSO5 To become familiar with modern Mathematics

Semester I

Mathematics I

(Differential Calculus of One variable and Special functions)

Code: MM 1131.6 Instructional hours per week: 5

No. of Credits 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Compute the limits and derivatives.

CO2 Explain the concept rate of change.

CO3 Analyse function behavior.

CO4 Understand basic concepts of some special functions.

Module I - Limits and continuity (24 Hours)

Definition of limits, One sided limits, two sided limits and infinite limits, computing limits, limits of polynomials and rational functions, limits involving radicals, limits of piecewise defined functions, limits at infinity. Continuity - Definition, continuity of polynomials and rational functions, continuity of compositions and continuity of Trigonometric functions.

Sections: 1.1, 1.2, 1.3, 1.5.1 to 1.5.6 and 1.6 of chapter 1 of text [1]

Module Specific Outcome

- A student should be able to apply limits to a wide variety of functions including piece wise, polynomial, rational and trigonometric. Also get a knowledge on continuity.

Module II - Differential Calculus of one variable (24 Hours)

Tangent lines, velocity, slopes and rates of change,rates of change in applications, Definition of the derivative function, computing instantaneous velocity, differentiability, relationship between differentiability and continuity, derivatives at the end points of an interval, other derivative notations, Techniques of differentiation, higher derivatives, product and quotient rule, derivatives of trigonometric functions, chain rule and implicit differentiation.

Sections : 2.1 to 2.7 of chapter 2 of text [1]

Module Specific Outcome

- A student should be able to compute derivatives of algebraic and trigonometric functions and calculate rates of changes related to day to day life.

Module III - Applications of Derivatives (24 Hours)

Increase and decrease functions, concavity, absolute maxima and minima, Rolle's theorem, Mean value theorem, L-Hospital's rule for evaluating limits in case of indeterminate forms.

Sections : 3.1, 3.2, 3.4, 3.5 and 3.8 of chapter 3 and 6.5 of chapter 6 in text [1].

Module Specific Outcome

- A student should be able to understand the various behavior of functions by applying derivative tests and evaluate the limits of indeterminate forms.

Module IV - Special Functions (18 Hours)

Factorial function, Definition of Γ function, recursion relation, Γ function of negative numbers, some important formulas involving gamma functions, β functions, β functions in terms of Γ functions.

Sections 11.1 to 11.7 of text [2].

Module Specific Outcome

- A student should be able to know about some special functions such as Γ and β.

Texts

Text 1 Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10^{th} Edition, John Wiley and Sons.

Text 2 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3^{rd} Edition, Wiley.

References

Ref. 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} Edition, Wiley-India.

Ref. 2 K F Riley, M P Hobson, S J Bence, *Mathematical methods for Physics and Engineering* 3^{rd} *Edition*, Cambridge University Press.

Ref. 3 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43^{rd} Edition, Khanna Publishers.

Semester II

Mathematics II

(Integral Calculus of One variable, Co ordinate Geometry and Complex Numbers)

Code: MM 1231.6 Instructional hours per week: 5

No. of Credits 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Explain the relationship between area and integral.

CO2 Compute integrals.

CO3 Compute area and volume using integration.

CO4 Understand basic concepts of co ordinate geometry.

Module I - Integral calculus of one variable (24 Hours)

Area problem, the rectangle method for finding areas, Indefinite integral (integration from the view point of differential equations, slope fields, integral curves are excluded) integration by substitution, The definite integral (section 4.5- up to theorem 4.5.6), Fundamental theorem of Calculus, relationship between definite and indefinite integrals, Mean value theorem for integrals (without proof), Evaluting definite integrals by substitution.

Sections : 4.1, 4.2, 4.3, 4.5, 4.6 and 4.9 of chapter 4 of text [1].

Module Specific Outcome

- A student should be able to get the thorough knowledge about integration.

Module II - Applications of Integration (24 Hours)

Area between two curves, Volumes by slicing disks and washers, volume by cylindrical shells, length of a plane curve, Area of surface of revolution.

Sections : 5.1 to 5.5 of chapter 5 of text [1].

Module Specific Outcome

- A student should be able to apply the concept of integration in a real life situation.

Module III - Foundations of coordinate geometry (24 Hours)

Parametric equations of a curve, orientation of a curve, expressing ordinary functions parametrically, tangent lines to parametric curves, arc length of parametric curves, Polar coordinate systems, relationship between polar and rectangular coordinate systems, graphs in polar coordinate system, symmetry test in polar coordinate system, tangent lines to polar curves, arc length of a polar curve, area in polar coordinates.

Sections : 10.1, 10.2 and 10.3 of chapter 10 of text [1].

Module Specific Outcome

- A student should be able to know the basics of coordinate geometry.

Module IV - Complex numbers (18 Hours)

Complex numbers, geometric representation of imaginary numbers, geometric representation of $z_1 + z_2$, De-Moivre's theorem (without proof), roots of a complex number, complex function, exponential function of a complex variable..

Sections : 19.1 to 19.8 of chapter 19 of text [2]

Module Specific Outcome

- A student can understand the basic concepts of Complex numbers, complex functions and evaluate the roots of a complex number.

Texts

Text 1 Howard Anton, Irl C.Bivens, Stephen Davis, *Calculus*, 10$^{\text{th}}$ Edition, John Wiley and Sons.

Text 2 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43$^{\text{rd}}$ Edition, Khanna Publishers.

References

Ref. 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10$^{\text{th}}$ Edition, Wiley-India.

Ref. 2 K F Riley, M P Hobson, S J Bence, *Mathematical methods for Physics and Engineering*, 3rd Edition, Cambridge University Press.

Ref. 3 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley.

Semester III

Mathematics III

(Differential Equations, Linear Equations, Abstract Algebra and Laplace Transforms)

Code: MM 1331.6 Instructional hours per week: 5

No. of Credits 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Describe a first order differential equation and solve it.

CO2 Analyse the consistency of system of linear equations and solve it.

CO3 Understand some algebraic concepts.

CO4 Understand and apply the concept Laplace transform.

Module I - First Order Ordinary Differential Equations (24 Hours)

Differential Equations of first order - Definitions, solution of a differential equations, equations of the first order and first degree variable separable, homogeneous equations, equations reducible to homogenous form, linear equations, Bernoulli's equations, exact differential equations, equations reducible to exact equations, equations of the first order and higher degree, Clairaut's equation.

Sections : Chapter 11 of text [1].

Module Specific Outcome

- A student should be able to understand, analyse and apply first order ordinary differential equations.

Module II - System of linear Equations (18 Hours)

Introduction to determinants and matrices, rank of a matrix, solution of linear system of equations (exclude matrix inversion method), consistency of linear system of equations, linear transformations, vectors, eigenvalues, properties of eigen values (statement only), Cayley Hamilton theorem (statement only).

Sections : 2.1, 2.2, 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14 and 2.15 of Chapter 2 of text[1]

Module Specific Outcome

- A student should be able to understand the concept of matrices and apply it to find the rank, solution and consistency of linear system of equations and the properties of eigen values.

Module III - Abstract Algebra (24 Hours)

Group- definition and examples, elementary properties, finite groups and subgroups, cyclic groups, elementary properties, result on order of elements.

Sections : 2, 4, 5 and 6 of text [2].

Module Specific Outcome

- A student should be able to understand concepts of group theory with examples.

Module IV - Laplace Transforms (24 Hours)

Definition, transforms of elementary functions, properties of Laplace transforms, transforms of periodic functions, transforms of special functions, transforms of derivatives and integrals, multiplication by t^n, division by t, Evaluation of integrals by Laplace transforms.

Sections : 21.1 and 21.11 of chapter 21 of text [1].

Module Specific Outcome

- A student should be able to know about the Laplace transforms and to solve related problems.

Texts

Text 1 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43rd Edition, Khanna Publishers.

Text 2 J B Fraleigh, *A First Course in Abstract Algebra*, 7th Edition, Pearson Education, INC.

References

Ref. 1 Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10th Edition, John Wiley and Sons.

Ref. 2 Peter V O Neil, *Advanced Engineering Mathematics*, Thompson publications, 2007.

Ref. 3 Mary L Boas *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley.

Ref. 4 Joseph Gallian, *Contemporary Abstract Algebra*, 8th Edition.

Semester IV

Mathematics IV

(Fourier Series, Vector Algebra, Vector Calculus and Theory of Equations)

Code: MM 1431.6 Instructional hours per week: 5

No. of Credits 4

Course Outcomes: After the completion of the course the students will be able to

CO1 Analyse Fourier Series.

CO2 Understand and apply basic operations among vectors.

CO3 Apply vector operators on scalar and vector point functions.

CO4 Understand the nature of roots fo polynomials and find approximate solutions.

Module I - Fourier Series (24 Hours)

Periodic functions, trigonometric series, Fourier series, Fourier coefficients, Euler formulas, periodic rectangular wave, derivation of Euler formulas, Arbitrary period, even and odd functions, half range expansions.

Sections : 11.1 and 11.2 of chapter 11 of text [2].

Module Specific Outcome

- A student should be able to know about the Fourier series and to solve related problems.

Module II - Vector Algebra (18 Hours)

Vectors, section formula,products of two vectors, Physical applications, scalar triple product, vector product of three vectors.

Sections: 3.1 to 3.10, text [1]

Module Specific Outcome

- A student should be able to understand analyse and apply various concepts of Vector Algebra.

Module III - Vector Calculus (24 Hours)

Differentiation of Vectors,curves in space, velocity and acceleration, scalar and vector point functions, del applied to scalar point functions - gradient and vector point functions, physical interpretation of divergence, del applied twice to point functions,product of point functions, line integral.

Sections 8.1 to 8.11, text [1].

Module Specific Outcome

- A student should be able to understand analyse and apply various concepts of vector calculus.

Module IV - Theory of Equations (24 Hours)

Fundamental theorem of Algebra(with out proof), relations between roots and coefficients of a polynomial, Reciprocal Equation, Descartes' rule of signs, finding approximate roots by bisection method and Newton - Raphson method. (Exclude symmetric functions of the roots, Sums of powers of the roots and Transformations of equations)

These topics can be found in text [3].

Module Specific Outcome

- A student should be able to understand nature of roots of polynomials, relation between roots and coefficients and applying methods to find approximate roots.

Texts

Text 1 Dr. B. S. Grewal, *Higher Engineering Mathematics* 43rd Edition, Khanna Publishers.

Text 2 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th Edition, Wiley-India.

Text 3 Barnard and Child, *Higher Algebra*, Mac Millan.

References

Ref. 1 Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10th Edition, John Wiley and Sons.

Ref. 2 Mary L Boas *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley.

First Degree Programme in

Computer Science

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

Sem	Course Code	Course Title	Instructional Hours per Week	Credit	Maximum Marks		
					CA	ESA	Total
I	MM 1131.10	Mathematics I	4	3	20	80	100
II	MM 1231.10	Mathematics II	4	3	20	80	100

PROGRAMME SPECIFIC OUTCOMES (PSO) FOR COMPLEMENTARY COURSE IN MATHEMATICS FOR FIRST DEGREE PROGRAMME IN COMPUTER SCIENCE

PSO1 To provide sufficient knowledge and skills in mathematics

PSO2 Students should be able to recall basic facts about mathematics and should be able to display knowledge of conventions such as notations and terminology

PSO3 Assimilate various graph theoretic concepts and familiarize with their applications

PSO4 Demonstrate proficiency in writing proofs

Semester I

Mathematics I

Code: MM1131.10 Instructional hours per week: 4

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 To familiarize participants with the scope and applications of Calculus

CO2 Explain the underlying concepts and tools in Discrete Mathematics with emphasis on their applications to Computer Science.

CO3 Describe Linear Algebra and its applications

Module I - Differentiation and its Applications (18 Hours)

Differentiation: Hyperbolic and inverse hyperbolic functions.
Applications: n^{th} - derivative of - polynomials, exponential, sine, cosine, Leibniz Theorem (Without Proof) and its applications

Module Specific Outcomes

- Understand the idea of differentiation.
- To Differentiate hyperbolic functions.
- Find n^{th} derivatives of functions

Text Book: Howard Anton, Irl C. Bivens, Stephen Davis, *Calculus*, 10^{th} Edition, John Wiley & Sons

Module II- Linear Algebra (18 Hours)

System of Linear equations, Solving System of Linear equations, Vectors, Scalars, Addition, Scalar multiplication, dot product, vector projection, Independence.
Matrices, Identity matrix, Inverse of a matrix, Rank of a matrix, Nullity, Trace of a matrix, eigen values, eigen vectors , Matrix decompositions and Cramers' rule.

Module Specific Outcomes:

- Understand the concept of linear algebra.

- Able to solve system of linear equations.
- Able to solve matrices.

Text Book: B. S. Grewal, *Higher Engineering Mathematics*, 43rd Edition, Khanna Publishers

Module III - Graph theory (18 Hours)

Basic concepts of graph theory, Graph terminology and Special types of graph, representation of graph, graph isomorphism, planar and non-planar graphs, Euler paths and circuits, Hamiltonian paths and circuits (without proofs), Trees, Spanning tree and theorems on trees.

Module Specific Outcomes:

- Able to define the basic concepts of graphs, directed graphs, and weighted graphs
- Understand the concepts of walk, path and cycle.
- Understand the basis of Trees and Spanning trees.

Text Book: Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*

Module IV - Number Theory (18 Hours)

Numbers: Euclid's Algorithm - GCD of 2 natural numbers, Divisors of a given natural number. Congruence's: Euler's function $\phi(n)$ and its properties (without proof of theorems), Fermat's and Wilson's Theorems, Euler's extension of Fermat's theorem (Only Statements) and its applications to find the remainder when divisible by a given number.

Module Specific Outcomes:

- Understand the concepts of divisibility and numbers theorems
- Able to calculate GCD using Euclid's Algorithm.
- Able to understand the concepts of theorems on numbers and their applications.

Text Book: Lindsey N Childs, *A concrete introduction to Higher Algebra*, Second Edition, Springer.

References

Ref. 1 Kennenth A Rosen, *Discrete Mathematics and its Applications*, Tata McGraw-Hill Publications Co. Ltd

Ref. 2 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} Edition, Wiley-India

Ref. 3 I. N. Herstein, *Topics in Algebra*, Second Edition, Wiley, 2006.

Ref. 4 J. P. Tremblay and R. Manohar, *Discrete Mathematical Structures with Application to Computer Science*, [Tata McGraw-Hill]

Semester II

Mathematics II

Code: MM 1231.10 Instructional hours per week: 4

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 Explain the underlying concept and tools in Discrete Mathematics with emphasis on their applications to Computer Science.

CO2 Understand the basic idea of set theory and group theory.

CO3 To learn how codes in mathematics are used for error correction and data transmission.

Module I - Mathematical Logic (18 Hours)

Proposition and Connectives : Conditional and Bi conditional Equivalence of Propositions, Tautology and Contradictions, Duality Theorem and its properties, Algebra of Proposition.
Normal Form: Principal Disjunctive, Principal Conjunctive Normal Forms and its applications using truth tables only.
Theory of Inference: Rules of Inference - Rule P, Rule T and Rule CP, Consistent and Inconsistent Premises, Indirect Method of Proof using these inference rules.

Module Specific Outcomes

- Understand the idea of proposition and connectives.
- Familiar with basic rules of logic.
- Apply the rules of inferences to solve problems

Text Book: T Veerarajan, *Discrete Mathematics with Graph Theory and Combinatorics*, Tata McGraw-Hill, New Delhi, 2007.

Module II - Predicate Logic (18 Hours)

Quantifiers: Essential and Universal quantifier, Free and Bound Variables.
Rules of Specifications: Rule US, ES, UG, EG. Using these, convert a given statement into symbolic notation. Derivation from Premises using truth table and without using truth table.

Module Specific Outcomes

- Understand the concept of Predicate logic.
- Able to solve system of logical problems using rules of Rules of Specifications.
- Able to derivation of conclusion from premises.

Text Book: T Veerarajan, *Discrete Mathematics with Graph Theory and Combinatorics*, Tata McGraw-Hill, New Delhi, 2007.

Module III - Set Theory (18 Hours)

Partition of Set: POSET - HASSE diagrams for partial ordering - lub, glb.
Lattices: Definition and Examples, principle of duality, Properties - Idempotency, commutativity, associativity, absorption (sub lattices excluded).
Group Theory: Definition, Examples, Order of a Group and its elements.

Module Specific Outcomes

- Able to define the basic concepts of Poset, lub and glb.
- Able to draw Hasse diagram on sets.
- Understand the basis of Group theory.

Text Book: Tremblery, R. Manohar, *TMH Discrete Mathematical Structures with Applications to CS.*

Module IV - Coding Theory and Combinatorics (18 Hours)

Coding Theory: Group Code, Encoders and Decoders, Hamming Codes - Hamming distance, decoding and encoding function - correction and detection of errors in Group Codes - parity check matrix and its properties.
Combinatorics: Recurrence relations of degree k with constant coefficients (Homogeneous and Non-Homogeneous) and its solutions (Non-homogeneous including Polynomial, exponential - excluding their product combinations)- Generating function Method of is also included

Module Specific Outcomes

- Understands the fundamentals of coding theory.
- Understand the concept of parity check matrix and its properties.
- To impart knowledge in combinatorics.

Text Book: T Veerarajan, *Discrete Mathematics with Graph Theory and Combinatorics*, Tata McGraw-Hill, New Delhi, 2007.

References

Ref. 1 Ralph P Grimaldi, B V Ramana, *Discrete and Combinatorial Mathematics*, 5^{th} Edition, Pearson Education.

Ref. 2 Keneth H Rosen, *Discrete Mathematics and its Applications*, Tata McGraw-Hill Pub.Co.Ltd.

Ref. 3 Seymour Lipschutz, Marc Lars Lipson, *Discrete Mathematics*, Schaum's Solved Problems, Series, McGraw-Hill International Editions

First Degree Programme in

Electronics

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

Sem	Course Code	Course Title	Instructional Hours per Week	Credit	Maximum Marks		
					CA	ESA	Total
I	MM 1131.1	Calculus with Applications - I	4	3	20	80	100
II	MM 1231.1	Calculus with Applications - II	4	3	20	80	100
III	MM 1331.6	Calculus and Linear Algebra	3	3	20	80	100

PROGRAMME SPECIFIC OUTCOMES (PSO) FOR COMPLEMENTARY COURSE IN MATHEMATICS FOR FIRST DEGREE PROGRAMME IN ELECTRONICS

PSO1 Develop familiarity with modern mathematics and provide strong foundation in mathematics

PSO2 Recognize and appreciate the connections between theories and applications

PSO3 Recognize the importance and value of mathematical thinking and approach to problem solving

PSO4 Formulate and analyze mathematical models of real life situations

Semester I

Mathematics I

Calculus with Applications - I

Code: MM 1131.1 Instructional hours per week: 4

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 To acquaint students with the scope and applications of Differential and Integral Calculus.

CO2 To develop an in-depth knowledge about the topics Complex numbers, Hyperbolic functions, Fourier series and Laplace transforms.

Module I - Differentiation with Applications (18 Hours)

(The following topics should be quickly reviewed before going to advanced topics; students should be asked to do more problems from exercises, and these problems should be included in assignments) Differentiation of products of functions; the chain rule; quotients; implicit differentiation; logarithmic differentiation; Leibnitz' theorem.

(The following topics in this module should be devoted more attention and time)

Special points of a function (especially, stationary points); curvature; theorems of differentiation – Rolle's Theorem, Mean Value Theorem.

The topics in this module can be found in chapter 2, sections 2.1.2, to 2.1.7, text [1] (Review of ideas through problems), chapter 2, sections 2.1.8, 2.1.9, 2.1.10, text [1] More exercises related to the topics in this module can be found in chapter 2 and chapter 3 of reference [1].

Module Specific Outcomes

- To understand various methods of differentiation.
- To use derivatives to find stationary points and curvature.
- To apply Rolle's Theorem and Mean Value Theorem for solving problems.

Module II - Integration with Applications (18 Hours)

Integration by parts; reduction formulae; infinite and improper integrals; plane polar coordinates; integral inequalities; applications of integration (finding area, volume etc).

The topics in this module can be found in chapter 2, sections 2.2.8 to 2.2.13, text [1].More exercises related to the topics in this module can be found in chapter 4, chapter 5 and chapter 7 of reference [1].

Module Specific Outcomes

- To familiarize with integral calculus.
- To apply the techniques in Integral Calculus to find area and volume.

Module III - Complex numbers and Hyperbolic functions (18 Hours)

Complex numbers, Basic operations(Addition and subtraction; modulus and argument; multiplication; complex conjugate; division), Polar representation of complex numbers (Multiplication and division in polar form), De Moivre's theorem (trigonometric identities; finding the nth roots of unity; solving polynomial equations), Complex logarithms and complex powers, Applications to differentiation and integration, Hyperbolic functions (Definitions; hyperbolic trigonometric analogies; identities of hyperbolic functions; inverses of hyperbolic functions; calculus of hyperbolic functions).

The topics in this module can be found in chapter 3, sections 3.1 to 3.7 of text [1] More exercises related to the topics in this module can be found in chapter 6 of reference [1] and chapter 13 of text [2].

Module Specific Outcomes

- To understand basic operations of complex numbers.
- To represent complex numbers in polar forms.
- To familiarize with hyperbolic and inverse hyperbolic functions.

Module IV - Fourier series and Laplace transforms (18 Hours)

Fourier series - Basic definition, Periodic Functions, Fourier Coefficients, Dirichlet Conditions, Even and Odd Functions, Half range series.
Laplace Transforms - Definition, Properties (Linearity property, Shifting property, Multiplication by powers of t, Laplace transform of derivatives),

Simple problems.

The topics in this module can be found in chapter 6 and chapter 11 of text [2].

Module Specific Outcomes

- To represent a function as a Fourier Series.
- To understand the concept of Laplace transforms.

Texts

Text 1 K F Riley, M P Hobson, S J Bence, *Mathematical methods for Physics and Engineering* 3*rd* *Edition*, Cambridge University Press.

Text 2 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th Edition, Wiley-India.

References

Ref. 1 H Anton, I Bivens, S Davis, *Calculus*, 10th Edition, John Wiley and Sons.

Ref. 2 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley.

Ref. 3 George B Arfken, Hans J Weber, Frank E Harris, *Mathematical Methods for Physicists*, 7th Edition, Academic Press

Semester II

Mathematics III

Calculus with Applications - II

Code: MM 1231.7 Instructional hours per week: 4

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 To acquaint students with vector algebra

CO2 To develop understanding about the difference between total and partial derivatives and to perform both operations.

CO3 To evaluate multiple integrals and apply it in relevant situations.

CO4 To develop knowledge and skill in vector calculus.

Module I - Vector Algebra (18 Hours)

Scalars and vectors, Addition and subtraction of vectors, Multiplication by a scalar, Basis vectors and components, Magnitude of a vector, Multiplication of vectors (Scalar product; vector product; scalar triple product; vector triple product), Equations of lines, planes and spheres, using vectors to find distances (Point to line; line to line).

The topics in this module can be found in chapter 7, sections 7.1 to 7.8, text [1] More exercises related to the topics in this module can be found in chapter 11 of reference [1] and chapter 6 of reference [2].

Module Specific Outcomes

- To perform vector operations.
- To use vectors to find distances.

Module II - Partial Differentiation (18 Hours)

Definition of partial derivative, The total differential and total derivative, Exact and inexact differentials, theorems of partial differentiation, The chain rule, Change of variables, Taylors theorem for many-variable functions, Stationary values of many-variable functions, Stationary values under constraints.

The topics in this module can be found in chapter 5, sections 5.1 to 5.9 of text [1] More exercises related to the topics in this module can be found in chapter 13 of reference [1]

Module Specific Outcomes

- To find partial derivatives using chain rule and by changing variables.
- To understand the applications of Partial Differential Calculus.

Module III - Multiple Integrals (18 Hours)

Double integrals, Triple integrals, Applications of multiple integrals (Areas and volumes), Change of variables in multiple integrals - Change of variables in double integrals; evaluation of some special infinite integrals, change of variables in triple integrals; general properties of Jacobians.

The topics in this module can be found in chapter 6, sections 6.1 to 6.4 of text [1] More exercises related to the topics in this module can be found in chapter 14 of reference [1].

Module Specific Outcomes

- To use multiple integrals to find areas and volumes.
- To make students capable of finding multiple integrals by changing variables.
- To know about the properties of Jacobians.

Module IV - Vector Calculus (18 Hours)

Differentiation of vectors - Composite vector expressions; differential of a vector, Integration of vectors, Space curves, Vector functions of several arguments, Surfaces, Scalar and vector fields Vector operators - Gradient of a scalar field; divergence of a vector field; curl of a vector field, Vector operator formulae - Vector operators acting on sums and products; combinations of grad, div and curl, Cylindrical and spherical polar coordinates

The topics in this module can be found in chapter 10, sections 10.1 to 10.9 of text [1]. More exercises related to the topics in this module can be found in chapter 3 of reference [3].

Module Specific Outcomes

- To perform differential and integral operations on vectors.

- To analyze scalar and vector fields,Vector differential operators Del and Laplacian operator.
- To know about cylindrical and spherical polar coordinates.

Texts

Text 1 K F Riley, M P Hobson, S J Bence, *Mathematical methods for Physics and Engineering*, 3rd Edition, Cambridge University Press.

References

Ref. 1 H Anton, I Bivens, S Davis, *Calculus*, 10th Edition, John Wiley and Sons.

Ref. 2 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley.

Ref. 3 George B Arfken, Hans J Weber, Frank E Harris, *Mathematical Methods for Physicists*, 7th Edition, Academic Press

Ref. 4 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th Edition, Wiley-India.

Semester III

Mathematics III

Calculus and Linear Algebra

Code: MM 1331.1 Instructional hours per week: 3

No. of Credits 3

Course Outcomes: After the completion of the course the students will be able to

CO1 To explain the underlying concepts and tools in Discrete Mathematics and their applications

CO2 To acquaint students with First order ordinary differential equations and their applications

CO3 To familiarize students with the scope and applications of Linear Algebra

Module I - Mathematical Logic (18 Hours)

Proposition and Connectives: Conditional and Bi-conditional Equivalence of Propositions, Tautology and Contradictions, Duality Theorem and its properties, Algebra of Proposition.
Normal Form: Principal Disjunctive, Principal Conjunctive Normal Forms and its applications using with and without truth tables
Theory of Inference: Rules of Inference - Rule P, Rule T and Rule CP, Consistent and Inconsistent premises, Indirect Method of Proof using these inference rules.

The topics in this module can be found in chapter 1 of text [3]. More exercises related to the topics in this module can be found in chapter 4 of reference [4].

Module Specific Outcomes

- To create awareness about basic terminologies used.
- To develop logical thinking.
- To apply inference theory on Propositional Logic.

Module II - Ordinary Differential Equations of First order (12 Hours)

First-order ordinary differential equations: General form of solution, First-degree first-order equations (Separable-Variable equations; Exact equations; inexact equations, integrating factors; linear equations; homogeneous equations; isobaric equations, Bernoulli's equation) Higher-degree first-order equations (Equations soluble for p; Clairaut's equation)

The topics in this module can be found in chapter 14 of text [1]. More exercises related to the topics in this module can be found in chapter 1, 2 and 3 of reference [1].

Module Specific Outcomes

- To understand various methods to solve first order differential equations.
- To enable students to apply differential equations for solving various physical problems.
- To know about Higher-degree first-order equations and their solutions.

Module III - Basic Linear Algebra (24 Hours)

Matrices and row reduction, Determinants, Cramer's rule for solving system of equations, vectors, lines and planes, linear combinations, linear functions, linear operators, linear dependence and independence, special matrices like Hermitian matrices and formulas, linear vector spaces, eigen values and eigen vectors, diagonalizing matrices, applications of diagonalization.

The topics in this module can be found in chapter 3 of text [2] More exercises related to the topics in this module can be found in chapter 7 and 8 of reference [1].

Module Specific Outcomes

- To understand the basic concepts of Matrices and Linear Algebra.
- To make students capable of solving system of linear equations.
- To familiarize with matrix diagonalization and its application.

Texts

Text 1 K F Riley, M P Hobson, S J Bence, *Mathematical methods for Physics and Engineering*, 3rd Edition, Cambridge University Press.

Text 2 Mary L Boas, *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley.

Text 3 T Veerarajan, *Discrete Mathematics with Graph Theory and Combinatorics*, Tata McGraw- Hill, New Delhi, 2007

References

Ref. 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th Edition, Wiley-India.

Ref. 2 H Anton, I Bivens, S Davis, *Calculus*, 10th Edition, John Wiley and Sons.

Ref. 3 George B Arfken, Hans J Weber, Frank E Harris, *Mathematical Methods for Physicists*, 7th Edition, Academic Press

Ref. 4 Seymour Lipschutz, Marc Lars Lipson, *Discrete Mathematics*, Schaum's Solved Problems Series, 3rd Edition, McGraw-Hill International Editions.