

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 - $\text{\LaTeX}$ 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 1661	Elective Course	3	2	20	80	100
	MM 1645	Programming with Python (Practical Examination only for $\text{\LaTeX}$ 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 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 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.

Texts

- Text 1** H Anton, I Bivens, S Davis, *Calculus Late Transcendentals*, 10th Edition, John Wiley & Sons.
- Text 2** S R Lay, *Analysis with an Introduction to Proof*, 5th Edition, Pearson Education Limited
- Text 3** Thomas Koshy, *Elementary Number Theory with Applications*, 2nd 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*, 12th Edition, Addison-Weseley Publishing Company.
- Ref. 3** J Stewart, *Calculus with Early Transcendental Functions*, 7th 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 Iannone, *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.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	1	3	0	0	1	2	2	1
CO2	3	3	3	3	1	3	2	2	1
CO3	1	3	3	3	1	2	2	2	1
CO4	2	2	2	2	0	1	1	2	1

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 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.

Texts

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

e-resources

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.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	3	1	0	2	2	2	1
CO2	2	3	3	2	1	2	2	2	2
CO3	3	2	3	2	2	1	2	2	1
CO4	2	0	1	2	1	1	2	1	1
CO5	1	3	2	2	1	0	1	2	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 remainder 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 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 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.

Texts

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

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

e-resources

1. <https://www.geogebra.org/m/xtbjxwmm>
2. <https://www.geogebra.org/m/VMa4z2RU>
3. <https://www.geogebra.org/m/wcjfy77h>

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	2	1	2	2	0	1	1	1	1
CO2	3	3	3	3	1	2	3	3	2
CO3	3	3	3	3	2	2	3	3	2
CO4	3	3	3	3	2	2	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 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.

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/wvvr8wxr>
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*, 2nd Edition, Springer.
- Ref. 8** David C Lay, *Linear algebra*, Pearson
- Ref. 9** T S Blyth, E F Robertson, *Linear Algebra*, Second Edition, Springer.
- Ref. 10** K Hoffman, R Kunze, *Linear algebra*, PHI.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	2	2	2	2	3	2	1
CO2	2	3	3	2	2	3	3	3	2
CO3	3	3	3	3	2	3	3	3	2
CO4	3	3	3	3	2	3	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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, Suprema, 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 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 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 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.

Texts

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

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	2	2	2	3	2	3	3	3	2
CO2	3	2	2	3	2	2	3	3	2
CO3	3	3	2	3	2	2	3	3	2
CO4	3	3	2	3	2	2	3	3	2
CO5	3	2	2	2	2	2	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 differentiability 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 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 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.

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*, 3rd Edition, Pearson Education India.
- Ref. 3** Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th 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*.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	2	2	2	3	2	3	3	3	1
CO2	2	2	2	3	2	2	3	3	2
CO3	3	2	2	3	2	2	3	3	2
CO4	3	3	2	3	2	2	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 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.

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.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	2	2	3	2	2	3	2	1
CO2	3	3	2	3	2	2	3	2	2
CO3	3	3	3	3	2	2	3	2	2
CO4	3	3	3	3	3	2	3	2	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 coefficients.

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 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.

Text

Text 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th 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*, 10th Edition, John Wiley & Sons 19.

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	3	2	2	2	3	3	2
CO2	3	3	3	2	2	3	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 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.

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*, 5th Edition.

Ref. 2 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. 3 David C Lay, *Linear Algebra*, Pearson.

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

Ref. 5 Thomas Banchoff, John Wermer, *Linear Algebra Through Geometry*, 2nd Edition, Springer.

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	3	2	2	2	3	3	2
CO2	3	3	2	2	2	2	3	3	2
CO3	3	2	3	2	2	3	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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, graphical 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 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 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.

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, 10th edition, 2016.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	2	3	3	3	2	3	3	2
CO2	3	3	3	3	2	2	3	3	3
CO3	3	2	3	3	2	2	3	3	2
CO4	3	3	3	2	2	2	3	2	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 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)

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*, 4th Edition, Mc-Graw Hill.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	3	3	2	2	3	3	2
CO2	3	3	3	3	2	2	3	3	2
CO3	3	2	3	3	2	2	3	3	3
CO4	3	3	3	2	2	2	3	2	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 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.

Texts

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

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

Reference

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	2	2	3	2	2	3	3	2
CO2	3	3	3	3	2	2	3	3	1
CO3	2	2	3	3	2	2	3	3	1
CO4	3	2	3	2	2	2	3	2	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

Semester V

Typesetting Scientific Documents with $\text{\LaTeX}$

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 $\text{\LaTeX}$ document.

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 $\text{\LaTeX}$ (6 Hours)

What is $\text{\LaTeX}$, Simple typesetting, Fonts, Type size

(Chapter 1 of Text 1)

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 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 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*)

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

Texts

Text 1 *The $\text{\LaTeX}$ Tutorial: A Primer*, by The Tutorial Team, Indian $\text{\TeX}$ Users 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 $\text{\LaTeX}2_{\epsilon}$* , Tobias Oetiker, Version 6.4, 09 March 2021

Ref. 2 Dilip Datta, *$\text{\LaTeX}$ in 24 Hours, A Practical Guide for Scientific Writing*, Springer, 2017

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	0	0	1	1	2	0	1	1	2
CO2	0	0	1	1	2	0	1	2	2
CO3	0	0	0	0	0	0	3	3	1

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

Semester VI

Real Analysis II

Code: 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 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 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.

Text

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	3	3	2	2	3	3	2
CO2	3	3	3	3	2	3	3	3	2
CO3	3	3	3	2	2	3	3	3	2
CO4	3	3	3	3	2	3	3	3	1

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 Taylor'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 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 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.

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*, 8th Edition, McGraw Hill International Edition.

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

Ref. 3 Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th 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*.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	1	2	2	2	2	2	2
CO2	3	3	2	2	2	3	3	3	2
CO3	3	3	3	2	2	3	3	3	2
CO4	3	3	3	3	2	3	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 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.

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.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	2	2	2	3	3	3	1
CO2	3	3	3	2	3	3	3	3	1
CO3	3	3	3	3	2	3	3	3	2
CO4	3	3	3	3	3	3	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 certain 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 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.]

Text

Text 1 Erwin Kreyszig, *Advanced Engineering Mathematics*, Wiley Publishers, 10th 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, 2nd 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.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	2	2	2	2	2	2	2	1
CO2	3	3	3	2	2	2	2	2	2
CO3	3	3	2	2	2	2	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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, bridges, 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 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.

Text

Text 1 Robin J. Wilson, *Introduction to Graph Theory*, Pearson Education Asia, 5th 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.

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	1	1	1	2	2	2	2	2	1
CO2	2	2	2	2	2	2	2	2	1
CO3	3	3	3	3	2	2	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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

Text

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

References

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

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	1	1	1	2	2	2	2	2	1
CO2	3	3	3	3	2	2	2	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 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 III – 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.

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	1	1	1	2	2	2	2	2	1
CO2	2	2	2	3	2	2	2	2	1
CO3	3	3	3	3	2	2	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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 acquainted 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 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 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 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")

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 L^AT_EX (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/>

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	3	3	3	2	2	2	3	3	2
CO2	3	3	3	3	2	3	3	3	2

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	2	2	2	3	2	3	3	3	3
CO2	0	0	1	3	3	2	3	3	3
CO3	3	3	3	3	2	3	3	3	3
CO4	3	3	3	3	2	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3

(0-No correlation, 1-Low Correlation, 2-Moderate Correlation, 3-High Correlation)