Board of Studies in Mathematics (UG)
UNIVERSITY OF KERALA

First Degree Programme in MATHEMATICS under Choice Based Credit and Semester System

REVISED SYLLABUS
2018 **admission**

Structure of Core Courses

Sem	Course Code	Course title	Instr.hrs. per week	Credit
I	MM 1141	Methods of Mathematics	4	4
II	MM 1221	Foundations of Mathematics	4	3
III	MM 1341	Elementary Number Theory and Calculus – I	5	4
IV	MM 1441	Elementary Number Theory and Calculus – I	5	4
V	MM 1541	Real Analysis – I	5	4
	MM 1542	Complex Analysis – I	4	3
	MM 1543	Abstract Algebra – Group Theory	5	4
	MM 1544	Differential Equations	3	3
	MM 1544	Mathematics Software – LaTeX & SageMath (Practical Examination Only)	4	3
	MM 1551	Open Course	3	2
	——	Project preparation - From selecting the topic to presenting the final report	1	
VI	MM 1641	Real Analysis – II	5	4
	MM 1642	Complex Analysis – II	4	3
	MM 1643	Abstract Algebra – Ring Theory	4	3
	MM 1644	Linear Algebra	5	4
	MM 1645	Integral Transforms	4	3
	MM 1651	Elective Course	3	2
	MM 1646	Project		4

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	Linear Programming with SageMath	3	2
VI	MM 1661.3	Numerical Analysis with SageMath	3	2
VI	MM 1661.4	Fuzzy Mathematics	3	2

Structure of the Complementary Courses

Complementary Course in Mathematics for First Degree Programme in Physics

Course Code	Sem.	Title of Course	Contact hrs/week	No. of Credits
MM 1131.1	1	Calculus with applications in Physics – I	4	3
MM 1231.1	2	Calculus with applications in Physics – II	4	3
MM 1331.1	3	Calculus and Linear Algebra	5	4
MM 1431.1	4	Complex Analysis, Special Functions and Probability Theory	5	4

Complementary Course in Mathematics for First Degree Programme in Chemistry

Course Code	Sem.	Title of Course	Contact hrs/week	No. of Credits
MM 1131.2	1	Calculus with applications in Chemistry – I	4	3
MM 1231.2	2	Calculus with applications in Chemistry – II	4	3
MM 1331.2	3	Linear Algebra, Probablity Theory & Numerical Methods	5	4
MM 1431.2	4	Differential Equations, Vector Calculus and Abstsract Algebra	5	4

Complementary Course in Mathematics for First Degree Programme in Geology

Course Code	Sem.	Title of Course	Contact hrs/week	No. of Credits
MM 1131.3	1	Algebra, Geometry and Trigonometry	4	3
MM 1231.3	2	Calculus and Linear Algebra	4	3
MM 1331.3	3	Complex Numbers, Algebra and Calculus	5	4
MM 1431.3	4	Basic Statistics and Differential Equations	5	4

Complementary Course in Mathematics for First Degree Programme in Statistics

Course Code	Sem.	Title of Course	Contact hrs/week	No. of Credits
MM 1131.4	1	Basic Calculus for Statistics	4	3
MM 1231.4	2	Advanced Differential and Integral Calculus	4	3
MM 1331.4	3	Fourier Series, Numerical Methods and ODE	5	4
MM 1431.4	4	Linear Algebra	5	4

Complementary Course in Mathematics for First Degree Programme in Economics

Course Code	Sem.	Title of Course	Contact hrs/week	No. of Credits
MM 1131.5	1	Mathematics for Economics I	3	2
MM 1231.5	2	Mathematics for Economics II	3	3
MM 1331.5	3	Mathematics for Economics III	3	3
MM 1431.5	4	Mathematics for Economics IV	3	3

Syllabus for the First Degree Programme in Mathematics of the University of Kerala

Semester I
Methods of Mathematics

CODE: MM 1141 — Instructional hours per week: 4
No.of credits: 4

In this paper, we quickly review the fundamental methods of solving problems viz. the limiting method, finding the rate of changes through differentiation method, and finding the area under a curve through the integration method.

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 non-linear 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 behaviour on various types of intervals, applications of extrema problems in finite 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;

Indeterminate forms and L'Hôpital's rule;
The topics to be discussed in this module can be found in chapter 2,3 and 6 of text [1] *below.*

Module II - Methods 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 substitition 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 travelled 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, 5, 6 and 7 of text [1] *below.*

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

References

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

Ref. 2 – G B Thomas, R L Finney. *Calculus*, 9th Edition, Addison-Weseley Publishing Company

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

Semester II

Foundations of Mathematics

CODE: MM 1221 Instructional hours per week: 4
No.of credits: 3

The rigorous study of mathematics begins with understanding the concepts of sets and functions. After that, one needs to understand the way in which a mathematician formally makes statements and proves or disproves it. We start this course with an introduction to these fundamental concepts. Apart from that, the basic of vector calculus is to be revised before moving to more advanced topics.

Module I - Foundations of Logic and Proof (36 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;

Sets and relations: A review of basic set operations like union, intersection, subset, superset concepts, equality of sets, complements, disjoint sets, indexed family of sets and operations on such families, ordered pairs, relations on sets, cartesian products (finite case only), various types of relations (reflexive, symmetric, transitive, equivalence), partitions of sets;

Functions: domain, codomain, range of functions, one-one, onto, bijective functions, image, preimage of functions, composing functions and the order of composition, inverse functions, cardinality of a set, equinumerous (equipotent) sets
The topics to be discussed in this module can be found in chapter 1 and 2 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 of text [2] *below.*

Module III - Foundations of vector calculus (18 Hours)
To begin with, the three dimesional rectangular co-ordinate system should be discussed and how distance is to be calculated between points in this sytem. 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 project should be given emphasize. Equations of lines determined by a point and vector, vector equations in lines, equatins of planes using vectors normal to be should be discussed. Quadric surfaces which are three dimensinal 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 of text [2] *below.*

Texts

Text 1 – S R Lay. *Analysis with an Introduction to Proof*, 5th Edition, Pearson Education Limited

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

References

Ref. 1 – J P D'Angelo, D B West. *Mathematical Thinking - Problem Solving and Proofs*, 2nd Edition, Prentice Hall

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

Ref. 3 – 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. 4 – G B Thomas, R L Finney. *Calculus*, 9th Edition, Addison-Weseley Publishing Company

Ref. 5 – J Stewart. *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited

Semester III

Elementary Number Theory and Calculus – I

Code: MM 1341 Instructional hours per week: 5
No.of credits: 4

Towards beginning the study on abstract algebraic structures, this course introduces the fundamental facts in elementary number theory. Apart from that, calculus of vector valued functions and multiple integrals is also discussed.

Module I - Divisibility in integers (18 Hours)
The topic of elementary number theory is introduced for further developing the ideas in abstract algebra. The following are the main topics in this module :
The division algorithm, Pigeonhole principle, divisibility relations, inclusion-exclusion principle, base-b representations of natural numbers, 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;

Linear Diophantine Equations and existence of solutions, Eulers Method for solving LDE's
The topics to be discussed in this module can be found in chapter 2 and 3 of text [2] *below.*

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 of text [1] *below.*

Module III - Multivariable Calculus (42 Hours)
After introducing the concept of functins of more than one variable, the sketching of them in three dimensinal 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 of text [1] *below.*

Texts

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

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

References

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

Ref. 2 – J Stewart. *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited

Ref. 3 – G A Jones, J M Jones. *Elementary Number Theory*, Springer

Semester IV

Elementary Number Theory and Calculus – II

CODE: MM 1441 | Instructional hours per week: 5
No.of credits: 4

As in the previous semester, towards beginning the study on abstract algebraic structures, this course introduces the fundamental facts in elementary number theory. Apart from that, calculus of vector valued functions and multiple integrals is also discussed.

Module I - Congruence relations in integers (30 Hours)
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, modulus exponentiation, finding reminder of big numbers using modular arithmetic, cancellation laws in modular arithmetic, linear congruences and existence of solutions, solving Mahavira's puzzle, modular inverses, Pollard Rho factoring method;

Certain tests for divisibility - The numbers here to test are powers of 2, 3, 5, 7, 9, 10, 11, testing whether a given number is a square;

Linear system of congruence equations, Chinese Remainder Theorem and some applications;

Some classical results like Wilson's theorem, Fermat's little theorem, Pollard $p - 1$ factoring method, Eulers' theorem,
The topics to be discussed in this module can be found in chapter 2 and 3 of text [2] *below.*

Module II - Multiple integrals (30 Hours)
Here we discuss double and triple integrals and their applications. The main topics in this module are the follwing:
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 variables.
The topics to be discussed in this module can be found in chapter 14 of text [1] *below.*

Module III - Vector Calculus (30 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 $\bigtriangledown$ operator, Laplacian;

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 of text [1] *below.*

Texts

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

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

References

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

Ref. 2 – J Stewart. *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited

Ref. 3 – G A Jones, J M Jones. *Elementary Number Theory*, Springer

Semester V

Real Analysis – I

CODE: MM 1541 Instructional hours per week: 5
No.of credits: 4

In this course, we discuss the notion of real numbers, the ideas of sequence of real numbers and the concept of infinite summation in a formal manner. Many of the topics discussed in the first two modules of this course were introduced somewhat informally in earlier courses, but in this course, the emphasis is on mathematical rigor. A minimal introduction to the metric space structure of $\mathbb{R}$ is also included so as to serve as a stepping stone into the idea of abstract topological spaces. The course is mainly based on Chapters 1–3 of text [1].

All the chapters mentioned above contains a section titled *Discussions* in the beginning of the chapter. This section is intended only for motivating the students, and so should not be made as a part of the examination process.

Module I (25 Hours)
This module introduces the basic concepts about the real number system with some introduction to sets, functions, and proof techniques. The following are the main topics to be discussed: existence of an irrational number, the axiom of completeness, upper lower bounds of sets in $\mathbb{R}$, consequences of completeness like Archimedian property of real numbers, Density of $\mathbb{Q}$ in $\mathbb{R}$, existence of square roots, countability of $\mathbb{Q}$ and uncountability of $\mathbb{R}$, various cardinality results, Cantor's original proof for uncoubtability of $\mathbb{R}$, and Cantor's theorem on power sets.
The topics to be discussed in this module can be found in chapter 1 of text [1] *below. The first section 1.1 may be briefly discussed and is not meant for examination purposes.*

Module II (40 hours)
Students must have already encountered the idea of infinite series through the example of geometric progression. After discussing the rearrangement concept of infinite series, the following topics are to be introduced rigourously : Limit of a sequence, diverging sequences, examples, algebraic operations on limits, and order properties of sequences and limits, the Monotone Convergence Theorem, Cauchy's condensation test for convergence of a series, various other tests for the convergence series, the Bolzano-Weierstrass theorem, the Cauchy criterion for convergence of a sequence, rearrangement of absolutely convergent series.

The topics to be discussed in this module can be found in chapter 2 of text [1] *below. The first section 2.1 may be briefly discussed and is not meant for examination purposes.*

Module III (25 hours)

This module is intended to be a beginner for learning abstract metric spaces. To motivate the students, the Cantor set should be constructed and shown in the beginning. Then move to the topics open and closed sets in $\mathbb{R}$, and what about their complements, Compactness of sets (defined using sequential convergence), open covers and compactness, perfect and connected sets in $\mathbb{R}$, and finally the Baire's theorem.
The topics to be discussed in this module can be found in chapter 3 of text [1] *below. The first section 3.1 may be briefly discussed and is not meant for examination purposes.*

Texts

Text 1 – Stephen Abbot. *Understanding Analysis*, 2nd Edition, Springer

References

Ref. 1 – R G Bartle, D Sherbert. *Introduction to Real Analysis*, 3rd Edition, John Wiley & Sons

Ref. 2 – W. Rudin. *Principles of Mathematical Analysis*, Second Edition, McGraw-Hill

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

Here we go through the basic complex function theory.

Module I (27 Hours)
Complex numbers : The algebra of Complex Numbers, Point Representation of Complex Numbers, Vectors and Polar forms, The Complex Exponential, Powers and Roots, Planar Sets
Analytic Functions : Functions of a complex variable, Limits and Continuity, Analyticity, The Cauchy Riemann Equations, Harmonic Functions
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 and chapter 2, sections 2.1, 2.2, 2.3, 2.4, 2.5 of text [1] *below.*

Module II (15 hours)
Elementary Functions : Polynomials and rational Functions (Proof of the theorem on partial fraction decomposition need not be discussed), The Exponential, Trigonometric and Hyperbolic Functions, The Logarithmic Function, Complex Powers and Inverse Trigonometric Functions.
The topics to be discussed in this module can be found in chapter 3, sections 3.1, 3.2, 3.3, 3.5 of text [1] *below.*

Module III (30)
Complex Integration : Contours, Contour Integrals, Independence of Path, Cauchy's Integral Theorem (Section 4.4a on deformation of Contours Approach is to be discussed, but section 4.4 b on Vector Analysis Approach need not be discussed), Cauchy's Integral Formula and Its Consequences, Bounds of Analytic Functions
The topics to be discussed in this module can be found in chapter 4, sections 4.1, 4.2, 4.3, 4.4a, 4.5 and 4.6 of text [1] *below.*

Texts

Text 1 – Edward B. Saff, Arthur David Snider. *Fundamentals of complex analysis with applications to engineering and science*, 3rd Edition, Pearson Education India

References

Ref. 1 – John H Mathews, Russel W Howell. *Complex Analysis for Mathematics and Engineering*, Jones and Bartlett Publishers

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

Ref. 3 – James Brown, Ruel Churchill. *Complex Variables and Applications*, Eighth Edition, McGraw-Hill

Semester V

Abstract Algebra – Group Theory

CODE: MM 1543 Instructional hours per week: 5
No.of credits: 4

The aim of this course is to provide a very strong foundation in the theory of groups. All the concepts appearing in the course are to be supported by numerous examples mainly from the references provided.

Module I (30 Hours)
The concept of group is to be introduced before rigorously defining it. The symmetries of a square can be a starting point for this. After that, definition of group should be stated and should be clarified with the help of examples. After discussing various properties of groups, finite groups and their examples 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 chapter 1, 2 3 and 4 of text [1] *below.*

Module II (24 Hours)
This module starts with defining and analysing various properties permutation groups which forms one of the most important class of examples for non abelian, finite groups. After defining operations on permutations, their properties are to be discussed. To motivate the students, the example of check-digit scheme should be discussed (This section on check-digit scheme is not meant for the examinations). Then we proceed to define the notion of equivalence of groups viz. isomorphisms. Several examples are to be discussed for explaining this notion. The properties of isomorphisms are also to be discussed together with special classes of isomorphisms like automorphisms and inner automorphisms before finishing the module with the classic result of Cayley on finite groups.
The topics to be discussed in this module can be found in chapter 5 and 6 of text [1] *below.*

Module III (18 Hours)
In this module we prove one of the most important results in group theory which is the Langrange's theorem on counting cosets of a finite group. The concept of cosets of a group should be defined giving many examples before proving the Lagrange's theorem. As some of the applications of this theorem, the connection between permutation groups and rotations of cube and soccer ball should be discussed. The section on Rubik's cube and section on internal direct products need not be discussed.
The topics to be discussed in this module can be found in chapter 7 and 9 of text [1] *below.*

Module IV (18 Hours)

Here the concept of group homomorphisms should be defined with sufficient number of examples. After proving the first isomorphism theorem, the fundamental theorem of isomorphism should be introduced and proved. Classifying groups based on the fundamental theorem should be discussed in detail.
The topics to be discussed in this module can be found in chapter 10 and 11 of text [1] *below.*

Texts

Text 1 – Joseph Gallian. *Contemporary Abstract Algebra*, 8th Edition, Cengage Learning

References

Ref. 1 – D S Dummit, R M Foote. *Abstract Algebra*, 3rd Edition, Wiley

Ref. 2 – I N Herstein. *Topics in Algebra*, Vikas Publications

Semester V

Differential Equations

CODE: MM 1544 | Instructional hours per week: 3
No.of credits: 3

In this course, we discuss how differential equations arise in various physical problems and consider some methods to solve first order differential equations and second order linear equations. For introducing the concepts, text [1] may be used, and for strengthening the theoretical aspects, reference [1] 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:
Modelling a problem, basic concept of a differential equation, its solution, initial value problems, geometric meaning (direction fields), seperable ODE, reduction to seperable 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 order ODE (18 hours)
As in the first module, we discuss second 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 order, initial value problem, basis, and general solutions, 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 w.r. to wronskian, solving nonhomogeneous ODE via the method of undetermined coefficients, varius applications of techniques, solution by variation of parameters.
The topics to be discussed in this module can be found in chapter 2 of text [1] *below.*

Texts

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

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

Semester V

Mathematics Software – LaTeX & SageMath

Code: MM 1545 — Instructional hours per week: 4
No.of credits: 3

Here we introduce two software which are commonly used by people working in Mathematics – a science typesetting software LaTeX, and a mathematical computation and visualization software SageMath. The aim of introducing LaTeX software is to enable students to typeset the project report which is a compulsory requirement for finishing their undergraduate mathematics programme succesfully. The aim of learning SageMath is to enable students to see how the computational techniques they have learned in the previous semesters can be put into action with the help of software so as to reduce human effort. Also, they should be able to use this software for further computations in their own in the forthcoming semester.

Module I - LaTeX for prearing a project report in Mathematics (36 Hours)

Graphical User Interface (GUI)/ Edtitor like Kile or TeXstudio should be used for providing training to the students. The main topics in this module are following:

Typesetting a simple article and compiling it;

How spaces are treated in the document;

Document layout : various options to be included in the `documentclass` command, page styles, splitting files into smaller files, breaking line and page, using boxes (like, `mbox`) to keep text unbroken across lines, dividing document in to parts like frontmatter, mainmatter, backmatter, chapters, sections, etc, cross referencing with and without page number, adding footnotes;

Emphasizing words with `\emph, \texttt, \textsl, \textit, \underline` etc.

Basic environments like `enumerate, itemize, description, flushleft, flusuright, center, quote, quotation`

Controlling enumeration via the `enumerate` package.

Tables : preparing a table and floating it, the longtable environment;

Typesetting mathematics : basic symbols, equations, operators, the `equation` environment and reference to it, the `displaymath` environment, exponents, arrows, basic functions, limits, fractions, spacing in the mathematics environments, matrices, aligning various objects, multi-equation environments, suppressing numbering for one or more equations, handling long equations, phantoms, using normal text in math mode, controlling font size, typesetting theorems, defintions, lemmas, etc, making text bold in math mode, inserting symbols and environments (`array, pmatrix` etc) using the support of GUIs;

Figures : Including JPG, PNG graphics with `graphicx` package, controlling width, height etc, floating figures, adding captions, the wrapfig package;

Adding references/bibliogrpahy and citing them, using the package `hyperref` to add and control hypertext links, creating presentations with `pdfscreen`, creating new commands;

Fonts : changing font size, various fonts, math fonts,

Spacing : changing line spacing, controlling horizontal, vertical spacing, controlling the margins using the geometry package, fullpage package

Preparing a dummy project with `titlepage`, acknowledgement, certificates, table of contents (using `\tableofcontents`), list of tables, table of figures, chapters, sections, bibliography (using the `thebibliography` environment). This dummy project should contain atleast one example from the each of the topic in the syllabus, and should be submitted for internal evaluation before the end semester practical examination.

Module II - Doing Mathematics with SageMath (36 hours)

Starting SageMath using a browser, how to use the sage cell server `https://sagecell.sagemath.org/`, how to use SageMathCloud, creating and saving a sage worksheet, saving the worksheet to an .sws file, moving it and re-opening it in another computer system;

Using sagemath as a calculator, basic functions (square root, logarithm, numeric value, exponential, trigonometric, conversion between degrees and radians, etc.);

Plotting : simple plots of known functions, controlling range of plots, controlling axes, labels, gridlines, drawing multiple plots on a single picture, *adding* plots, polar plotting, plotting implicit functions, contour plots, level sets, parametric 2D plotting, vector fields plotting, gradients;

Matrix Algebra : Adding, multiplying two matrices, row reduced echelon forms to solve linear system of equations, finding inverses of square matrices, determinants, exponentiation of matrices, computing the kernel of a matrix;

Defining own functions and using it, composing functions, multi variate functions;

Polynomials : Defining polynomials, operations on them like multiplication and division, expanding a product, factorizing a polynomial, finding gcd;

Solving single variable equations, declaring multiple variables, solving multi variable equations, solving system of non linear equations, finding the numerical value of roots of equations;

complex number arithmetic, finding complex roots of equations;

Finding derivatives of functions, higher order derivatives, integrating functions, definite and indefinite integrals, numerical integration, partial fractions and integration,

Combinatorcs & Number theory: Permutations, combinations, finding gcd, lcm, prime factorization, prime counting function, n^{th} prime funcion, divisors of a number, counting divisors, modular arithmetic;

Vector calculus : Defining vectors, operations like sum, dot product, cross product, vector valued functions, divergence, curl, multiple integrals;

Computing Taylor, McClaurins polynomials, minimization and Lagrange multipliers, constrained and unconstrained optimization;

Internal Evaluation : A dummy project report prepared in LaTeX should be submitted as assignment for internal evaluation for 5 marks. Another practical record should be submitted the content of which should be problems and their outputs evaluated using SageMath. This record should be awarded a maximum of 10 marks which is earmarked for the internal evaluation examination.

Problems to be included in the examination:

1. Find all local extrema and inflection points of a function
2. Traffic flow optimization
3. Minimum surface area of packaging
4. Newton's method for finding approximate roots
5. Plotting and finding area between curves using integrals
6. Finding the average of a function
7. Finding volume of solid of revolution
8. Finding solution for a system of linear equations
9. Finding divergence and curl of vector valued functions
10. Using differential calculus to analyze a quintic polynomials features, for finding the optimal graphing window
11. Using Pollard's $p - 1$ Method of factoring integers, to try to break the RSA cryptosystem
12. Expressing gcd of two integers as a combination of the integers (Bezout's identity)

References

Ref. 1 – Tobias Oetiker, Hubert Partl, Irene Hyna and Elisabeth Schlegl. *The (Not So) Short Introduction to LaTeX2e*, Samurai Media Limited (or available online at http://mirrors.ctan.org/info/lshort/english/lshort.pdf)

Ref. 2 – Leslie Lamport. *LaTeX: A Document Preparation System*, Addison-Wesley, Reading, Massachusetts, second edition, 1994

Ref. 3 – *LaTeX Tutorials—A Primer*, Indian TeX Users Group, available online at https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf

Ref. 4 – H. J. Greenberg. *A Simplified introduction to LaTeX*, available online at https://www.ctan.org/tex-archive/info/simplified-latex/

Ref. 5 – *Using Kile - KDE Documentation*, https://docs.kde.org/trunk4/en/extragear-office/kile/quick_using.html

Ref. 6 – *TeXstudio : user manual*, http://texstudio.sourceforge.net/manual/current/usermanual_en.html

Ref. 7 – *The longtable package - TeXdoc.net*, http://texdoc.net/texmf-dist/doc/latex/tools/longtable.pdf

Ref. 8 – *wrapfig - TeXdoc.net*, http://texdoc.net/texmf-dist/doc/latex/wrapfig/wrapfig-doc.pdf

Ref. 9 – *The geometry package*, http://texdoc.net/texmf-dist/doc/latex/geometry/geometry.pdf

Ref. 10 – *The fullpage package*, http://texdoc.net/texmf-dist/doc/latex/preprint/fullpage.pdf

Ref. 11 – *The SageMathCloud*, https://cloud.sagemath.com/

Ref. 12 – Gregory V. Bard. *Sage for Undergraduates*, American Mathematical Society, available online at http://www.gregorybard.com/Sage.html

Ref. 13 – Tuan A. Le and Hieu D. Nguyen. *SageMath Advice For Calculus* available online at http://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf

Semester V

Operations Research (Open Course)

CODE: MM 1551.1 | Instructional hours per week: 3
No. of Credits: 2

Module I – Linear Programming (18 hours)
Formulation of Linear Programming models, Graphical solution of Linear Programs in two variables, Linear Programs in standard form - basic variable - basic solution- basic feasible solution -feasible solution, Solution of a Linear Programming problem using simplex method (Since Big-M method is not included in the syllabus, avoid questions in simplex method with constraints of $\geq$ or $=$ type.)

Module II – Transportation Problems (18 hours)
Linear programming formulation - Initial basic feasible solution (Vogel'sapproximation method/North-west corner rule) - degeneracy in basic feasible solution - Modified distribution method - optimalitytest.

ASSIGNMENT PROBLEMS: Standard assignment problems - Hungarian method for solving an assignment problem.

Module III – Project Management (18 hours)
Activity -dummy activity - event - project network, CPM (solution by network analysis only), PERT.

The topics to be discussed in this course can be found in text [1].

Texts

Text 1 – Ravindran, Philps, Solberg. *Operations Research- Principles and Practice*, 2nd Edition, Wiley India Pvt Ltd

References

Ref. 1 – Hamdy A. Taha. *Operations Research : An Introduction*, 9th Edition, Pearson

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, say in the fields general finance and basic sciences.

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

References

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

Semester V

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

Instructional hours per week: 1

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 5th semester itself, and should end towards the middle of the 6th semester. This course (without any examination in the 5th semester, with a project report submissin and project viva in the 6th semester) 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

Texts

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 & 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

Semester VI

Real Analysis – II

Code: MM 1641 | Instructional hours per week: 5
No.of credits: 4

In the second part of the Real Analysis course, we focus on functions on $\mathbb{R}$, their continuity, existence of derivatives, and integrability. The course is mainly based on Chapters 4,5 and 7 of text [1].

All the chapters mentioned above contains a section titled *Discussions* in the beginning of the chapter. These sections are intended only for motivating the students, and so should not be made a part of the examination process.

Module I (35 Hours)

Here we move towards the basic notion of limits of functions and their continuity. Various version of definition of limits are to be discussed here. The algebra of limits of functions and the divergence criterion for functional limits are to be discussed next. The other topics to be discussed in this module are the discontinuity criterion, composition of functions and continuity, continuity and compct sets, results on uniform continuity, the intermediate value theorem, Monotone functions and their continuity.

The topics to be discussed in this module can be found in chapter 4 of text [1] *below. The first section 4.1 may be briefly discussed and is not meant for examination purposes.*

Module II (25 hours)

Here we discuss the derivative concept more rigorously than what was done in the previous calculus courses. After (re)introducing the definition of differentiability of functions, we verify that differentiability implies continuity. Algebra and composing of differentiable functions should be discussed next. The interior extremum theorem and Darboux's theorem should be discussed after that. The mean value theorems should be discussed and proved, and the module ends with L'Hospitals results. A continuous everywhere but notwhere differentiable function should be discussed, but it is not meant for the examination. It may be infact used for student seminars.

The topics to be discussed in this module can be found in chapter 5 of text [1] *below. The sections 5.1 and 5.4 may be briefly discussed and is not meant for examination purposes.*

Module III (30 hours)

In the last module, the theory of Riemann integration is to be discussed. Main topics to be included in this module are defining the Riemann integral using upper, lower Riemann sums, and the integrability criterion, continuity and the existence of integral, algebraic operations on integrable functions, (The results and examples on convergence of sequence of functions and integrability may be omitted), the fundamental theorem of calculus and its proof, Lebesgue's criterion for Riemann integrability.

The topics to be discussed in this module can be found in chapter 7 of text [1] *below. The first section 7.1 may be briefly discussed and is not meant for examination purposes.*

Texts

Text 1 – Stephen Abbot; *Understanding Analysis*, 2nd Edition, Springer

References

Ref. 1 – R G Bartle, D Sherbert ; *Introduction to real analysis*, 3rd Edition, John Wiley & Sons

Ref. 2 – W. Rudin, *Principles of Mathematical Analysis*, Second Edition, McGraw-Hill

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

Module I (32 Hours)
Series Representations for Analytic Functions : Sequences and Series, Taylor Series, Power Series, Mathematical Theory of Convergence, Laurent series, Zeros and Singularities, The point at Infinity. *The topics to be discussed in this module can be found in chapter 5, sections 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7 of* text [1] *below.*

Module II (20 Hours)
Residue Theory : The Residue Theorem, Trigonometric Integrals over $[0, 2\pi]$, Improper integrals of Certain functions over $[-\infty, \infty]$, Improper integrals involving Trigonometric Functions, Indented Contours
The topics to be discussed in this module can be found in chapter 6, sections 6.1, 6.2, 6.3, 6.4, 6.5 of text [1] *below.*

Module III (20 Hours)
Conformal Mapping : Geometric Considerations, Mobius Transformations
The topics to be discussed in this module can be found in chapter 7, sections 7.2, 7.3, 7.4 of text [1] *below.*

Texts

Text 1 – Edward B. Saff, Arthur David Snider. *Fundamentals of complex analysis with applications to engineering and science*, 3rd Edition, Pearson Education India

References

Ref. 1 – John H Mathews, Russel W Howell. *Complex Analysis for Mathematics and Engineering*, 6th Edition, Jones and Bartlett Publishers

Ref. 2 – Murray R Spiegel. *Complex variables: with an introduction to conformal mapping and its applications*, Schaum's outline.

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

Ref. 4 – James Brown, Ruel Churchill. *Complex Variables and Applications*, Eighth Edition, McGraw-Hill

Semester VI

Abstract Algebra – Ring Theory

CODE: MM 1643 | Instructional hours per week: 4
No.of credits: 3

After discussing the theory of groups thoroughly in the previous semester, we move towards the next higher algebraic structure rings. As in the last semester, all the new concepts appearing in the course is to be supported by numerous examples mainly from the references provided.

Module I (24 Hours)
The concept of rings, subrings with many examples should be discussed here. Next comes the definition and properties of integral domains, fields, and the characteristic of rings. Ideals, how factor rings are defined using ideals, should be explained next. The definition of prime and maximal ideals with examples should be discused after that.
The topics to be discussed in this module can be found in chapter 12, 13 and 14 of text [1] *below.*

Module II (24 Hours)
After introducing the definition of ring homomorphisms, their properties should be discussed. The field of quotients of an integral domain should be discussed next. The next topic is the definition and various properties of polynomial rings over a commutative ring. Various results on operations on polynomials such as division algorithm, factor theorem, remainder theorem etc should be discussed next. The definition and examples of PID's should be discussed next, before moving to the factorization of polynomials. Tests of irreducibility and reducibility and the unique factorization of polynomials over special rings should be discused. .
The topics to be discussed in this module can be found in chapter 15, 16 and 17 of text [1] *below.*

Module III (24 Hours)
In the last module, we introduce more rigorous topics like various type of integral domains. The divisibility properties of integral domains and definition of primes in a general ring should be introduced. Unique factorization domains and the Euclidean domains should be discussed next with examples. Results on these special integral domains are aslo to be discussed.
The topics to be discussed in this module can be found in chapter 18 of text [1] *below.*

Texts

Text 1 – Joseph Gallian; *Contemporary Abstract Algebra*, 8th Edition, Cengage Learning

References

Ref. 1 – D S Dummit, R M Foote; *Abstract Algebra*, 3rd Edition, Wiley

Ref. 2 – I N Herstein, *Topics in Algebra*, Vikas Publications

Semester VI

Linear Algebra

Code: MM 1644 | Instructional hours per week: 5
No.of credits: 4

The main focus of this course is to introduce linear algebra and methods in it for solving practical problems.

Module I (15 Hours)
This module deals with a study on linear equations and their geometry. After introducing the geometrical intrepretation of linear equations, following topics should be discussed: various operations on column vectors, technique of Gaussian elimination, operations involving elementary matrices, interchanging of rows using elementary matrices, triangular factorisation of matrices and finding inverse of matrices by the elimination method.
The topics to be discussed in this module can be found in chapter 1 of text [1] *below. The section 1.7 may be omitted.*

Module II (25 hours)
Towards the study of vector spaces, specifically $\mathbb{R}^n$, we define them with many examples. Subspaces are to be defined next. After discussing the idea of nullspace of a matrix. The solving linear equations (which was one to some extent in the first module) and finding solutions to non-homogeneous systems from the corresponding homogeneous systems. After this, linear independence and dependence of vectors, their spanning, basis for a space, its dimension concepts are to be introduced. The column, row, null, left null spaces of a matrix is to be discussed next. When inverses of a matrix exists related to its column/row rank should be discussed. Towards the end of this module, linear transformations (through matrices) and their properties are to be discussed. Types of transformations like rotations, projections, reflections are to be considered next.
The topics to be discussed in this module can be found in chapter 2 of text [1] *below. The section 2.7 on graphs and networks may be omitted.*

Module III (25 hours)
This module is intended for making the idea and concepts of determinants stronger. Its properties like what happens when rows are interchanged, linearlity of expansion along the first row, etc are to be discussed. Breaking a matrix into triangular, diagonal forms and finding the determinants, expansion in cofactors, their applications like solving system of equations, finding volume etc are to be discussed next.
The topics to be discussed in this module can be found in chapter 4 of text [1] *below.*

Module IV (25 hours)
Here we conclude our analysis of matrices. The problem of finding eigen values a matrix is to be introduced first. Next goal is to diagonalize a matrix. This concept should be

discussed first, and move to the discussion on the use of eigen vectors in diagonalization. Applications of finding the powers of matrices should be discussed next. The applications like the concept of Markov Matrices, Positive Matrices and their applications in Economics should be discussed. Complex matrices and operations on them are to be introduced next. The concept orthoganality of vectors may be required here from one of the previous sections in text [1] and it should be briefly introduced and discussed here. The module ends with similar matrices, and similarity transformation related ideas. How to diagonalize some special matrices like symmetric and Hermitial matrices are also to be discussed in this module.
The topics to be discussed in this module can be found in chapter 5 of text [1] *below. The section 5.4 on applications to differential equations may be omitted*

Texts

Text 1 – Gilbert Strang, *Linear Algebra and Its Applications*, 4th Edition, Cengage Learning

References

Ref. 1 – *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. 2 – Thomas Banchoff, John Wermer; *Linear Algebra Through Geometry*, 2nd Edition, Springer

Ref. 3 – T S Blyth, E F Robertson: *Linear Algebra*, Springer, Second Edition.

Ref. 4 – David C Lay: *Linear Algebra*, Pearson

Ref. 5 – K Hoffman and R Kunze: *Linear Algebra*, PHI

Semester VI

Integral Transforms

CODE: MM 1645 — Instructional hours per week: 4
No.of credits: 3

After completing courses in ordinary differential equations and basic integral calculus, we see here some of its applications.

Module I (38 Hours)

Laplace Transforms : 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 the Integral of a Function, Differential Equations, Initial Value Problems, Unit Step Function (Heaviside Function), Second Shifting Theorem ($t-$Shifting) Time Shifting ($t-$Shifting): Replacing t by $t-a$ in $f(t)$, Short Impulses. Diracs Delta Function. Partial Fractions Convolution , Application to Nonhomogeneous Linear ODEs, Differentiation and Integration of Transforms, ODEs with Variable Coefficients, 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 [1] below.

Module II (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, From Fourier Series to Fourier Integral, Applications of Fourier Integrals, Fourier Cosine Integral and Fourier Sine Integral, Fourier Cosine and Sine Transforms, Linearity, Transforms of Derivatives, 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 text [1] below.

Texts

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

References

Ref. 1 – Peter V. O' Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

Ref. 2 – M Greenberg, *Advanced Engineering Mathematics*, 2nd Edition, Prentice Hall

Semester VI

Graph Theory (Elective)

CODE: MM 1661.1 | Instructional hours per week: 3
No. of credits: 2

Overview of the Course: The course has been designed to build an awareness of some of the fundamental concepts in Graph Theory and to develop better understanding of the subject so as to use these ideas skillfully in solving real world problems.

Module I (27 Hours)
Basics : The Definition of a Graph, Graphs as Mathematical Models, other basic concepts and definitions, Vertex Degrees, Subgraphs, Paths and Cycles, The Matrix Representation of Graphs, Fusing graphs (The fusion algorithm for connectedness need not be discussed).

Trees and Connectivity : Definitions and Simple Properties of trees, Bridges, Spanning Trees, Cut Vertices and Connectivity *The topics in this module can be found in Chapter 1, Sections 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7 and 1.8, Chapter 2, Sections 2.1, 2.2, 2.3 and 2.6 of* text [1].

Module II (27 Hours)
Euler Tours and Hamiltonian Cycles : Euler Tours (Fleury's algorithm need not be discussed), The Chinese Postman Problem (Only Statement of the problem is to be discussed) , Hamiltonian Graphs, The Travelling Salesman Problem (Only Statement of the problem is to be discussed, The Two-Optimal Algorithm and The Closest Insertion Algorithm need not be discussed)

Planar Graphs : Plane and Planar Graphs, Euler's Formula, The Platonic Bodies, Kuratowski's Theorem (Without proof).

The topics in this module can be found in Chapter 3, Sections 3.1, 3.2, 3.3 and 3.4, Chapter 5, Sections 5.1, 5.2, 5.3 and 5.4 of text [1].

Texts

Text 1 – John Clark, Derek Allan Holton. *A first look at Graph Theory*, World Scientific

References

Ref. 1 – R Balakrishnan, Ranganatahan. *A Text Book of Graph Theory*, 2nd Edition, Springer

Ref. 2 – V K Balakrishnan. *Graph Theory*, Schaums Outline

Ref. 3 – J A Body, U S R Murthy. *Graph Theory with Applications*, The Macmillan Press

Ref. 4 – Robin J Wilson. *Introduction to Graph Theory* 5th edition, Prentice Hall

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester I

Mathematics – I
(Calculus with applications in Physics – I)
Code: MM 1131.1

Instructional hours per week: 4 No. of Credits:3

Module 1: Differentiation with applications to Physics (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 – Rolles', Mean Value Theorems
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 2: Integration with applications to Physics (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 3: Infinite series and limits (18 Hours)
Definition, Summation of series of various types (Arithmetic series; geometric series; arithmetico-geometric series; the difference method; series involving natural numbers; transformation of series) Convergence of infinite series (Absolute and conditional convergence; series containing only real positive terms; alternating series test)
Operations with series (Sum and product)
Power series (Convergence of power series; operations with power series)
Taylor series (Taylors theorem need not be proved, but the statement should be explained through problems); approximation errors; standard Maclaurin series
The topics in this module can be found in chapter 4, sections 4.1 to 4.6, text [1]
More exercises related to the topics in this module can be found in chapter 9 of text [1] *and chapter 1 of* text [2].

Module 4: 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; point to plane; line to line; line to plane)

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].

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 & 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

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester II

Mathematics – II
(Calculus with applications in Physics – II)

Code: MM 1231.1

Instructional hours per week: 4 No. of Credits: 3

Module 1 : Complex numbers and hyperbolic functions (18 hours)
Basic operations (Addition and subtraction; modulus and argument; multiplication; complex conjugate; division), Polar representation of complex numbers (Multiplication and division in polar form), de Moivers 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; hyperbolictrigonometric analogies; identities of hyperbolic functions; solving hyperbolic equations; 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 text [1] *and chapter 13 of reference [4].*

Module 2 : Partial differentiation (18 Hours)
Basics, 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 3 : 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 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 4 : Vector differentiation (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].

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 & 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

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester III

Mathematics – III
(Calculus and Linear Algebra)

Code: MM 1331.1

Instructional hours per week: 5 No. of Credits: 4

Module 1 : Ordinary Differential Equations (30 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; Bernoullis equation; miscellaneous equations) Higher-degree first-order equations (Equations soluble for p; for x; for y; Clairaut's equation)

Higher-order ordinary differential equations : Linear equations with constant coefficients, (Finding the complementary function $y_c(x)$; finding the particular integral $y_p(x)$; constructing the general solution $y_c(x) + y_p(x)$; linear recurrence relations; Laplace transform method) Linear equations with variable coefficients (The Legendre and Euler linear equations; exact equations; partially known complementary function; variation of parameters; Green's functions; canonical form for second-order equations)

General ordinary differential equations – Dependent variable absent; independent variable absent; non-linear exact equations; isobaric or homogeneous equations; equations homogeneous in x or y alone; equations having $y = Ae^x$ as a solution
The topics in this module can be found in chapter 14 and chapter 15 of text [1]
More exercises related to the topics in this module can be found in chapter 1, 2 and 3 of reference [4].

Module 2 : Vector Integration – Line, surface and volume integrals (18 hours)
Evaluating line integrals; physical examples; line integrals with respect to a scalar Connectivity of regions, Greens theorem in a plane, Conservative fields and potentials, Surface integrals, Evaluating surface integrals; vector areas of surfaces; physical examples, Volume integrals, Volumes of three-dimensional regions, Integral forms for grad, div and curl, Green's theorems (without proof); other related integral theorems; physical applications, Stokes theorem and related theorems (without proof), Related integral theorems; physical applications
The topics in this module can be found in chapter 11 of text [1]
More exercises related to the topics in this module can be found in chapter 3 of reference [3].

Module 3 : Fourier series (18 Hours)
Basic definition, Simple Harmonic Motion and Wave Motion; Periodic Functions, Applications of Fourier Series, Average Value of a Function, Fourier Coefficients, Dirichlet Conditions, Complex Form of Fourier Series, Other Intervals, Even and Odd Functions, Parsevals Theorem, Fourier Transforms
The topics in this module can be found in chapter 7 of text [2]

More exercises related to the topics in this module can be found in chapter 11 of reference [4].

Module 4 : 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 [4].

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 & 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

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester IV

Mathematics – IV
(Complex Analysis, Special Functions, and Probability Theory)

Code: MM 1431.1

Instructional hours per week: 5 No. of Credits: 4

Module 1 : Advanced Complex Analysis (36 Hours)
Functions of a complex variable, Analytic functions, the Cauchy-Riemann relations, Contour integrals Cauchy's theorem, Cauchy's integral formula, Laurent series, the residue theorem, methods of finding residues, evaluation of definite integrals using residue theorem, residues at infinity, conformal mapping and some of its applications.
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 14, 15, 16 and 17 of reference [4].

Module 2 : Special functions (18 Hours)
The Factorial Function, Definition of the Gamma Function; Recursion Relation, The Gamma Function of Negative Numbers, Some Important Formulas Involving Gamma Functions, Beta Functions, Beta Functions in Terms of Gamma Functions
The topics in this module can be found in chapter 11 of text [1]
More exercises related to the topics in this module can be found in chapter 13 of reference [3].

Module 3 : Probability and Statistics (36 Hours)
Basics, Sample Space, Probability Theorems, Methods of Counting Random Variables, Continuous Distributions, Binomial Distribution, The Normal or Gaussian Distribution, The Poisson Distribution
The topics in this module can be found in chapter 15, sections 15.1 to 15.9 of text [1]
More exercises related to the topics in this module can be found in chapter 23 of reference [3].

Texts

Text 1 – Mary L Boas. *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley

References

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

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

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

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Chemistry

Semester I

Mathematics – I
(Calculus with applications in Chemistry – I)
Code: MM 1131.2

Instructional hours per week: 4 No. of Credits:3

Module 1: Differentiation with applications to Chemistry (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 – Rolles', Mean Value Theorems
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 2 : Complex numbers and hyperbolic functions (18 hours)
Basic operations (Addition and subtraction; modulus and argument; multiplication; complex conjugate; division), Polar representation of complex numbers (Multiplication and division in polar form), de Moivers 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; hyperbolictrigonometric analogies; identities of hyperbolic functions; solving hyperbolic equations; 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 reference [4].

Module 3: Basic 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; point to plane; line to line; line to plane)
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 4: Basic integration with applications to Chemistry (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, 5 and 7 of reference [1].

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 & 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

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Chemistry

Semester II

Mathematics – II
(Calculus with applications in Chemistry – II)

Code: MM 1231.2

Instructional hours per week: 4 No. of Credits: 3

Module 1 : Partial differentiation (18 Hours)
Basics, 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 2: Infinite series and limits (18 Hours)
Definition, Summation of series of various types (Arithmetic series; geometric series; arithmetico-geometric series; the difference method; series involving natural numbers; transformation of series) Convergence of infinite series (Absolute and conditional convergence; series containing only real positive terms; alternating series test)
Operations with series (Sum and product)
Power series (Convergence of power series; operations with power series)
Taylor series (Taylors theorem need not be proved, but the statement should be explained through problems); approximation errors; standard Maclaurin series
The topics in this module can be found in chapter 4, sections 4.1 to 4.6, text [1]
More exercises related to the topics in this module can be found in chapter 9 of reference [1] and chapter 1 of reference [2].

Module 3 : Vector differentiation (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 4 : 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 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].

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 & 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

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Chemistry

Semester III

Mathematics – III
(Linear Algebra, Probablity Theory & Numerical Methods)

Code: MM 1331.2

Instructional hours per week:5 No. of Credits: 4

Module 1 : 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 [3].

Module 2 : Probability and Statistics (36 Hours)
Basics, Sample Space, Probability Theorems, Methods of Counting Random Variables, Continuous Distributions, Binomial Distribution, The Normal or Gaussian Distribution, The Poisson Distribution
The topics in this module can be found in chapter 15, sections 15.1 to 15.9 of text [2]
More exercises related to the topics in this module can be found in chapter 23 of reference [2].

Module 3 : Numerical Methods (30 Hours)
Algebraic and transcendental equations (Rearrangement of the equation; linear interpolation; binary chopping; Newton-Raphson method)
Convergence of iteration schemes, Simultaneous linear equations (Gaussian elimination; Gauss-Seidel iteration; tridiagonal matrices) Numerical integration (Trapezium rule; Simpsons rule; Gaussian integration; Monte Carlo methods), Finite differences, Differential equations (Difference equations; Taylor series solutions; prediction and correction;Runge–Kutta methods; isoclines)
The topics in this module can be found in chapter 27, sections 27.1 to 27.6 of text [1]
More exercises related to the topics in this module can be found in reference [4].

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

References

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

Ref. 2 – George B Arfken, Hans J Weber, Frank E Harris. *Mathematical Methods for Physicists*, 7th Edition, Academic Press

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

Ref. 4 – Richard L Burden, J Douglas Faires. *Numerical Analysis*, 9th Edition, Cengate Learning

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Chemistry

Semester IV

Mathematics-IV
(Differential Equations, Vector Calculus, and Abstsract Algebra)

Code: MM 1431.2

Module 1 : Ordinary Differential Equations (30 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; Bernoullis equation; miscellaneous equations) Higher-degree first-order equations (Equations soluble for p; for x; for y; Clairaut's equation)

Higher-order ordinary differential equations : Linear equations with constant coefficients, (Finding the complementary function $y_c(x)$; finding the particular integral $y_p(x)$; constructing the general solution $y_c(x) + y_p(x)$; linear recurrence relations; Laplace transform method) Linear equations with variable coefficients (The Legendre and Euler linear equations; exact equations; partially known complementary function; variation of parameters; Green's functions; canonical form for second-order equations)

General ordinary differential equations – Dependent variable absent; independent variable absent; non-linear exact equations; isobaric or homogeneous equations; equations homogeneous in x or y alone; equations having $y = Ae^x$ as a solution
The topics in this module can be found in chapter 14 and chapter 15 of text [1]
More exercises related to the topics in this module can be found in chapter 1, 2 and 3 of reference [3].

Module 2 : Vector Integration – Line, surface and volume integrals (18 hours)
Evaluating line integrals; physical examples; line integrals with respect to a scalar Connectivity of regions, Greens theorem in a plane, Conservative fields and potentials, Surface integrals, Evaluating surface integrals; vector areas of surfaces; physical examples, Volume integrals, Volumes of three-dimensional regions, Integral forms for grad, div and curl, Green's theorems (without proof); other related integral theorems; physical applications, Stokes theorem and related theorems (without proof), Related integral theorems; physical applications
The topics in this module can be found in chapter 11 of text [1]
More exercises related to the topics in this module can be found in chapter 3 of reference [2].

Module 3: Abstract Algebra (42 Hours)
Definition of a group; examples of groups, Finite groups, Non-Abelian groups, Permutation groups, Mappings between groups, Subgroups Subdividing a group (Equivalence relations and classes; congruence and cosets; conjugates and classes)

Representation theory, Equivalent representations, Reducibility of a representation, The orthogonality theorem for irreducible representations Characters (Orthogonality property of characters), Counting irreps using characters (Summation rules for irreps), Con-

struction of a character table
The topics in this module can be found in chapter 28 and chapter 29, sections 29.3, 29.4, 29.5, 29.6, 29.7, 29.8 of text [1]
More exercises related to the topics in this module can be found in reference [5].

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 & 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

Ref. 5 – David M Bishop. *Group theory and Chemistry*, Dover Publications

Board of studies in Mathematics (UG)

UNIVERSITY OF KERALA

First Degree Programme in

MATHEMATICS

under Choice Based Credit and Semester System

Revised Syllabus of Complementary Mathematics

for Physics, Chemistry, Statistics and Economics Core

for 2021 admission onwards.

MM 1131.1 -(1/2)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester I

Mathematics – I
(Calculus and sequences and series)
Code: MM 1131.1

Instructional hours per week: 4 No. of Credits:3

Overview of the course:
This course is designed to get a fairly descent coverage of calculus of one or more variables. A short section on sequences and series is also included. As this course is designed as a complementary course for students of B.Sc. Physics, we may avoid all the proofs of theorems.

Module 1: Differential calculus of one variable (18 Hours)

We start with definition of limits as in 1.1.1 and then move on to discussion on one sided limits, two sided limits and infinite limits, techniques for computing limits may be done as in section 1.2. Limits at infinity for polynomials, rational functions and functions involving radicals are to be discussed as in section 1.3. A general discussion on continuity may be done as in section 1.5. Various techniques for differentiation are to be covered using section 2.1 to to 2.8. This portion will cover the product and quotient rules, derivatives of trigonometric functions, chain rule and implicit differentiation. Basic properties of exponential and logarithemic functions and techniques of differentiation involving these functions may be explored asin sections 6.1 and 6.2. Definition Evaluating and derivatives of inverse trigonometric functions has to be discussed as in section 6.7.

The topics in this module can be found in chapter 1; sections 1.1, 1.2, 1.3, 1.5, chapter 2; sections 2.1 to 2.7 and chapter 6; sections 6.1, 6.2 and 6.7 of text [1].

Module 2 : Integral calculus of one variable (18 Hours)
We start this module with an introduction to indefinite integral as in section 4.2. Integration techniques like substitution, hyperbolic functions, integration by parts, trigonometric substitution and partial fractions has to be dealt as in sections 4.3, 4.5, 4.6, 4.9, 6.8 and 7.1 to 7.5.
The topics in this module can be found in chapter 4; sections 4.2, 4.3, 4.5, 4.6, 4.9 Chapter 6; section 6.8 and chapter 7, sections 7.1 to 7.5 of text [1]

Module 3: Differential calculus of functions of two or more variables (18 Hours)

This module begins with a study of functions of two or more independent variables. We describe the domains, graphs and level curves of such functions as in section 13.1. A discussion about partial differentiation, without going into analytic details of continuity of partial derivatives can be conducted as in section 13.3. Discuss problem 94 of exercise set 13.3. A very short, but important mention has to be made about total differential of a function of two or more variables as in section 13.4 (definition of total differential only). Chain rule for partial differentiation can be practiced as in section 13.5. It is suggestible to transform 'Laplace's' and 'Cauchy-Riemann' equations from cartesian to polar forms (problems 55 and 57 of exercise set 13.5). Section 13.8 can be used to provide a good course on maxima and minima of function of two or more variables. Section 13.9 will introduce the reader to Lagrange Multiplier metod for constrained optimization. Problem 34 in exercise set 13.9 will provide an easy application of this method.

The topics in this module can be found in chapter 13, sections 13.1, 13.3, 13.4, 13.5, 13.8 and 13.9 of text [1]

Module 4: Sequences and series (18 Hours)

Section 9.1 will introduce the reader to sequences, their limits, convergence and some related theorems. Infinite series, thier convergence and sums, telescoping sums, geometric and harmonic series can be discussed as in section 9.3. Sections 9.4 and 9.5 will present various tests for cheking convergence of infinite series. Section 9.6 discusses alternating series. Sections 9.7 and 9.8 discusses polynomials and series known by the names of Taylor and Maclaurin.

The topics in this module can be found in chapter 9, sections 9.1, and 9.3 to 9.8 of text [1]

Texts

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

References

Ref. 1 – George B. Thomas, Ross L. Finney. Calculus and analytic geometry, 9th Edition, Addison-wesley publishing Company.

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

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

MM 1231.1 -(1/2)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester II

Mathematics – II
(Applications of calculus and vector differentiation)

Code: MM 1231.

Instructional hours per week: 4 — No. of Credits: 3

Overview of the course:
This course is designed to get a fairly descent coverage of integral calculus of one or more variables and vector differentiation. As this course is designed as a complementary course for students of B.Sc. Physics, we may avoid all the proofs of theorems.

Module 1 : Applications of derivatives (18 hours)

Properties of functions like increase, decrease, concavity, maxima and minima has to be analyzed as in sections 3.1, 3.2 and 3.4. Rolle's theorem and mean value theorem has to be discussed as in section 3.8. This section ends with L'Hōpital's rule for evaluating limits in case of indeterminate forms as in section 6.5.

The topics in this module can be found in chapters 3 and 6 within sections 3.1, 3.2, 3.4, 3.8, and section 6.5 of text [1]

Module 2: Applications of integration (18 Hours)

We can proceed as in section 5.1 to find area between two curves. Sections 5.2 and 5.3 discuss two method to find volumes involving integration in one variable. Arc lengths of curves and area of revolution must be covered as in section 5.4 and 5.5. The use of differentiation and integration to get new power series from already known series has to be discussed as in section 9.10. In exercise set 9.10 problem 41 on carbon dating and problem 44 on gravity has to be mentioned.

The topics in this module can be found in chapter 5, sections 5.1 to 5.5 and chapter 9.10 of text [1]

Module 3 : Multiple Integrals (18 Hours)

A basic introduction to double integrals can be given as in sections 14.1 and 14.2. For the purpose of evaluatingdouble integral in polar coordinates as in 14.3, we shall first give an introduction to polar coordinates as in section 10.2. For evaluating double integrals to find surface area and tripple integrals to find volume as in sections 14.4 and 14.5, a basic knowledge of quadric surfaces is necessary as in section 11.7. For performing integrations in cylindrical and spherical coordinates as in section 14.6 and change of variable as in section 14.7, we first build up a knowledge on these coordinates as in section 11.8.

The topics in this module can be found in chapter 14; sections 14.1 to 14.7, chapter 10 section 10.2 and chapter 11; sections 11.7 and 11.8 of text [1].

Module 4 : Vector differentiation (18 Hours)

After an introduction to vector valued functions as in section 12.1, we can move to derivatives of such functions as in section 12.2. Vector equations of tangent lines to graphs

MM 1231.1. — (2/2)

and derivatives of dot and cross products of functions are to be discussed; while results on integration may be avoided. Section 13.6 will provide enough material on directional derivatives and vector operator - gradient. Besides the usual exercise problems; problems 73, 74, and 76 of excercise set 13.6 may be discussed.
The topics in this module can be found in chapter 12; sections 12.1, 12.2, and chapter 13; section 13.6 of text [1].

Texts

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

References

Ref. 1 – George B. Thomas, Ross L. Finney. Calculus and analytic geometry, 9th Edition, Addison-wesley publishing Company.

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

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

MM 1331.1 —(1/2)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester III

Mathematics III
(Linear Algebra, Special Functions and Calculus)

Code: MM 1331.1 **Instructional hours per week: 5** **No. of Credits: 4**

Module 1 : Linear Algebra : Determinants, Matrices (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, Eigen Values, Properties of Eigen Values (Statements only), Cayley-Hamilton Theorem (Statement only), Reduction to Diagonal Form.

The topics in this section can be found in chapter 2 [sections 2.1, 2.2, 2.4, 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16] of text [1].

Module 2 : Ordinary Differential Equations (36 Hours)

- Differential Equations of the First Order :- Definitions, Solution of a Differential Equation, Equations of the First order and First Degree Variables Separable, Homogeneous Equations, Equations Reducible to Homogeneous Form, Linear Equations, Bernoulli's Equation, Exact Differential Equations, Equations reducible to exact equations, Equations of the First Order and Higher Degree, Clairaut's Equation.
- Applications of Differential Equations of First Order :- Orthogonal Trajectories.
- Linear Differential Equations :- Definitions, Theorem without proof, Operator D, Rules For Finding the Complementary Function, Inverse Operator, Rules for Finding the Particular Integral, Working Procedure to Solve the Equation, Two Other Methods of Finding P.I, Equations reducible to Linear equations with Constant Coefficients, Linear Dependence of Solutions.

The topics in this module can be found in chapter 11 [sections 11.1, 11.4-11.14], chapter 12 [section 12.3] and chapter 13 [sections 13.1-13.10] of text [1].

Module 3 : Vector Integration and Special Functions (30 hours)

Vector Integration

Vector Fields, Line Integrals, Independence of Path and Conservative Vector Fields, Green's theorem, Surface Integrals, Applications of Surface Integrals; The Divergence Theorem, Stokes' Theorem.

MM 1331.1 — (2/2)

[All theorems in this section should be discussed without proof].
The topics in this section can be found in chapter 15 [sections 15.1 to 15.8] of text [2].

Special Functions

The Factorial Function, Definition of the Gamma Function; Recursion Relation, The Gamma Function of Negative Numbers, Some Important Formulas Involving Gamma Functions, Beta Functions, Beta Functions in Terms of Gamma Functions.

The topics in this section can be found in chapter 11 [sections 2 to 7] of text [3].

Text [1] : B.S. Grewal, Higher Engineering Mathematics, 42nd Edition, Khanna Publishers.

Text [2] : Howard Anton, Irl Bivens, Stephen Davis. Calculus, 10th Edition, John Wiley & Sons.

Text [3] : Mary L. Boas. Mathematical Methods in the Physical Sciences, Third Edition, John Wiley & Sons.

References

I) K. F. Riley, M. P. Hobson, S.J. Bence. Mathematical Methods for Physics and Engineering, 3rd Edition, Cambridge University Press.

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

III) Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley-India.

MM 1431.1 –(1/2)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Physics

Semester IV

Mathematics - IV
(Fourier Series, Complex Analysis and Probability Theory)

Code: MM 1431.1 **Instructional hours per week: 5** **No. of Credits: 4**

Module 1: Fourier Series (24 Hours)

Introduction, Euler's Formulae (without proof), Conditions for a Fourier Expansion, Functions Having Points of Discontinuity, Change of Interval, Even and Odd Functions, Half Range Series, Fourier Transforms, Properties of Fourier Transforms.

The topics in this module can be found in chapter 10 [sections 10.1 to 10.7] and Chapter 22 [sections 22.4, 22.5] of the text.

Module 2 : Complex Analysis (36 Hours)

Complex Numbers and Functions :- 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.

Calculus of Complex Functions :- Introduction, Limit of a Complex Function, Derivative of f(z), Analytic Functions, Harmonic Functions, Complex Integration, Cauchy's Theorem, Cauchy's Integral Formula, Laurent's Series, Zeros of an Analytic Function, Residues, Calculation of Residues, Evaluation of Real Definite Integrals.

[All Theorems in this module should be considered without proof]
The topics in this module can be found in chapter 20 [sections 20.1 to 20.5, 20.12 to 20.14, 20.16 (Laurent Series only), 20.17 to 20.20] of the text.

Module 3: Probability and Statistics (30Hours)

Probability and Distributions :- Introduction, Basic Terminology, Probability and Set Notations, Addition Law of Probability, Independent Events, Baye's Theorem, Random Variable, Discrete Probability Distribution, Continuous Probability Distribution, Binomial Distribution, Poisson Distribution, Normal Distribution.

The topics in this module can be found in chapter 26 [sections 26.1 to 26.9, 26.14 to 26.16] of the text.

Text : B.S. Grewal, Higher Engineering Mathematics, 42nd Edition, Khanna Publishers.

References

I) K.F. Riley, M. P. Hobson, S .J. Bence. Mathematical Methods for Physics and Engineering, 3rd Edition, Cambridge University Press.

II) H. Anton, I. Bivens, S. Davis. Calculus, 10th Edition, John Wiley & Sons.

III) George. B. Afken, Hans. J. Weber, Frank .E. Harris. Mathematical Methods for Physicists, 7th Edition, Academic Press.

IV) Erwin Kreyszig. Advanced Engineering Mathematics, 10th Edition, Wiley-India.

V) Mary L. Boas. Mathematical Methods in the Physical Sciences, Third Edition, John Wiley & Sons.

MM 1131.2 -(1/2)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Chemistry

Semester I

Mathematics – I
(Differential Calculus and sequences and series)
Code: MM 1131.2

Instructional hours per week: 4 No. of Credits:3

Overview of the course:
This course is designed to get a fairly descent coverage of differential calculus of one or more variables. A short section on sequences and series is also included. As this course is designed as a complementary course for students of B.Sc. Chemistry, we may avoid all the proofs of theorems.

Module 1: Differential calculus of one variable (18 Hours)

We start with definition of limits as in 1.1.1 and then move on to discussion on one sided limits, two sided limits and infinite limits, techniques for computing limits may be done as in section 1.2. Limits at infinity for polynomials, rational functions and functions involving radicals are to be discussed as in section 1.3. A general discussion on continuity may be done as in section 1.5. Various techniques for differentiation are to be covered using section 2.1 to to 2.8. This portion will cover the product and quotient rules, derivatives of trigonometric functions, chain rule and implicit differentiation. Basic properties of exponential and logarithemic functions and techniques of differentiation involving these functions may be explored asin sections 6.1 and 6.2 (avoid results on integration). Definition Evaluating and derivatives of inverse trigonometric functions has to be discussed as in section 6.7 (avoid results on integration).

The topics in this module can be found in chapter 1; sections 1.1, 1.2, 1.3, 1.5, chapter 2; sections 2.1 to 2.7 and chapter 6; sections 6.1, 6.2 and 6.7 of text [1].

Module 2 : Applications of derivatives (18 hours)

Properties of functions like increase, decrease, concavity, maxima and minima has to be analyzed as in sections 3.1, 3.2 and 3.4. Rolle's theorem and mean value theorem has to be discussed as in section 3.8. This section ends with L'Höpital's rule for evaluating limits in case of indeterminate forms as in section 6.5.

The topics in this module can be found in chapters 3 and 6 within sections 3.1, 3.2, 3.4, 3.8, and section 6.5 of text [1]

Module 3: Differential calculus of functions of two or more variables (18 Hours)

This module begins with a study of functions of two or more independent variables. We describe the domains, graphs and level curves of such functions as in section 13.1. A discussion about partial differentiation, without going into analytic details of continuity of partial derivatives can be conducted as in section 13.3. Discuss problem 94 of exercise set 13.3. A very short, but important mention has to be made about total differential of

MM 1131.2 – (2/2)

a function of two or more variables as in section 13.4 (definition of total differential only). Chain rule for partial differentiation can be practiced as in section 13.5. It is suggestible to transform 'Laplace's' and 'Cauchy-Riemann' equations from cartesian to polar forms (problems 55 and 57 of exercise set 13.5). Section 13.8 can be used to provide a good course on maxima and minima of function of two or more variables. Section 13.9 will introduce the reader to Lagrange Multiplier metod for constrained optimization. Problem 34 in exercise set 13.9 will provide an easy application of this method.

The topics in this module can be found in chapter 13, sections 13.1, 13.3, 13.4, 13.5, 13.8 and 13.9 of text [1]

Module 4: Sequences and series (18 Hours)

Section 9.1 will introduce the reader to sequences, their limits, convergence and some related theorems. Infinite series, thier convergence and sums, telescoping sums, geometric and harmonic series can be discussed as in section 9.3. Sections 9.4 and 9.5 will present various tests for cheking convergence of infinite series. Section 9.6 discusses alternating series. Sections 9.7 and 9.8 discusses polynomials and series known by the names of Taylor and Maclaurin.

The topics in this module can be found in chapter 9, sections 9.1, and 9.3 to 9.8 of text [1]

Texts

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

References

Ref. 1 – George B. Thomas, Ross L. Finney. Calculus and analytic geometry, 9th Edition, Addison-wesley publishing Company.

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

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

MM 1231.2 –(1/1)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Chemistry

Semester II

Mathematics – II
(Integral calculus and vector differentiation)

Code: MM 1231.2

Instructional hours per week: 4 No. of Credits: 3

Overview of the course:
This course is designed to get a fairly descent coverage of integral calculus of one or more variablesand vector differentiation. As this course is designed as a complementary course for students of B.Sc. Chemistry, we may avoid all the proofs of theorems.

Module 1 : Integral calculus of one variable (18 Hours)
We start this module with an introduction to indefinite integral as in section 4.2. Integration techniques like substitution, hyperbolic functions, integration by parts, trigonometric substitution and partial fractions has to be dealt as in sections 4.3, 4.5, 4.6, 4.9, 6.8 and 7.1 to 7.5.
The topics in this module can be found in chapter 4; sections 4.2, 4.3, 4.5, 4.6, 4.9 Chapter 6; section 6.8 and chapter 7, sections 7.1 to 7.5 of text [1]

Module 2: Applications of integration (18 Hours)
We can proceed as in section 5.1 to find area between two curves. Sections 5.2 and 5.3 discuss two method to find volumes involving integration in one variable. Arc lengths of curves and area of revolution must be covered as in section 5.4 and 5.5. The use of differentiation and integration to get new power series from already known series has to be discussed as in section 9.10. In exercise set 9.10 problem 41 on carbon dating and problem 44 on gravity has to be mentioned.
The topics in this module can be found in chapter 5, sections 5.1 to 5.5 and chapter 9.10 of text [1]

Module 3 : Multiple Integrals (18 Hours)
A basic introduction to double integrals can be given as in sections 14.1 and 14.2. For the purpose of evaluatingdouble integral in polar coordinates as in 14.3, we shall first give an introduction to polar coordinates as in section 10.2. For evaluating double integrals to find surface area and tripple integrals to find volume as in sections 14.4 and 14.5, a basic knowledge of quadric surfaces is necessary as in section 11.7. For performing integrations in cylindrical and spherical coordinates as in section 14.6 and change of variable as in section 14.7, we first build up a knowledge on these coordinates as in section 11.8.
The topics in this module can be found in chapter 14; sections 14.1 to 14.7, chapter 10 section 10.2 and chapter 11; sections 11.7 and 11.8 of text [1].

Module 4 : Vector differentiation (18 Hours)
After an introduction to vector valued functions as in section 12.1, we can move to derivatives of such functions as in section 12.2. Vector equations of tangent lines to graphs and derivatives of dot and cross products of functions are to be discussed; while results

on integration may be avoided. Section 13.6 will provide enough material on directional derivatives and vector operator - gradient. Besides the usual exercise problems; problems 73, 74, and 76 of excercise set 13.6 may be discussed.
The topics in this module can be found in chapter 12; sections 12.1, 12.2, and chapter 13; section 13.6 of text [1].

Texts

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

References

Ref. 1 – George B. Thomas, Ross L. Finney. Calculus and analytic geometry, 9th Edition, Addison-wesley publishing Company.

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

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

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Semester III

Mathematics - III
(Linear Algebra, Probablity Theory & Numerical Solutions)

Code: MM 1331.2 **Instructional hours per week: 5** **No. of Credits: 4**

Module 1 : Linear Algebra : Determinants, Matrices (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, Eigen Values, Properties of Eigen Values (Statements only), Cayley-Hamilton Theorem (Statement only), Reduction to Diagonal Form.

The topics in this section can be found in chapter 2 [sections 2.1, 2.2, 2.4, 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16] of the text.

Module 2: Probability and Statistics (30 Hours)

Probability and Distributions :- Introduction, Basic Terminology, Probability and Set Notations, Addition Law of Probability, Independent Events, Baye's Theorem, Random Variable, Discrete Probability Distribution, Continuous Probability Distribution, Binomial Distribution, Poisson Distribution, Normal Distribution.

The topics in this module can be found in chapter 26 [sections 26.1 to 26.9, 26.14 to 26.16] of the text.

Module 3: Numerical Solutions (36 Hours)

- Numerical Solution of Equations :- Introduction, Solution of Algebraic and Transcendental equations, Useful Deductions From the Newton-Raphson Formula, Solution of Linear Simultaneous Equations, Direct Methods of Solution (exclude Factorization Method), Iterative Methods of Solution (exclude relaxation method).
- Finite Differences and Interpolation :- Finite Differences, To Find One or More Missing Terms (First method only), Newton's Interpolation Formulae, Lagrange's Interpolation Formula.
- Numerical Integration :- Numerical Integration, Trapezoidal Rule, Simpson's One-Third Rule, Simpson's Three-Eighth Rule, Weddle's Rule.
- Numerical Solution of Ordinary Differential Equations :- Taylor's Series Method, Runge-Kutta Method, Predictor-Corrector Methods, Milne's Method.

The topics in this module can be found in chapter 28 [sections 28.1 to 28.3, 28.5 to 28.7], chapter 29 [Sections 29.1, 29.5, 29.6, 29.10], chapter 30 [sections 30.4, 30.6 to 30.8, 30.10] and chapter 32 [sections 32.3, 32.7 to 32.9] of the text.

Text : B.S. Grewal, Higher Engineering Mathematics, 42nd Edition, Khanna Publishers.

References

I) K.F. Riley, M. P. Hobson, S .J. Bence. Mathematical Methods for Physics and Engineering, 3rd Edition, Cambridge University Press.

II) H. Anton, I. Bivens, S. Davis. Calculus, 10th Edition, John Wiley & Sons.

III) George. B. Afken, Hans. J. Weber, Frank .E. Harris. Mathematical Methods for Physicists, 7th Edition, Academic Press.

IV) Erwin Kreyszig. Advanced Engineering Mathematics, 10th Edition, Wiley-India.

V) Mary L. Boas. Mathematical Methods in the Physical Sciences, Third Edition, John Wiley & Sons.

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Semester IV

Mathematics-IV
(Differential Equations, Vector Calculus, and Abstract Algebra)

Code: MM 1431.2 **Instructional hours per week: 5** **No. of Credits: 4**

Module 1 : Ordinary Differential Equations (36 Hours)

Differential Equations of the First Order :- Definitions, Solution of a Differential Equation, Equations of the First order and First Degree Variables Separable, Homogeneous Equations, Equations Reducible to Homogeneous Form, Linear Equations, Bernoulli's Equation, Exact Differential Equations, Equations reducible to exact equations, Equations of the First Order and Higher Degree, Clairaut's Equation.
Applications of Differential Equations of First Order :- Orthogonal Trajectories.
Linear Differential Equations :- Definitions, Theorem without proof, Operator D, Rules For Finding the Complementary Function, Inverse Operator, Rules for Finding the Particular Integral, Working Procedure to Solve the Equation, Two Other Methods of Finding P.I, Equations reducible to Linear equations with Constant Coefficients, Linear Dependence of Solutions.

The topics in this module can be found in chapter 11 [sections 11.1, 11.4-11.14], chapter 12 [section 12.3] and chapter 13 [sections 13.1-13.10] of text [1].

Module 2 : Vector Integration (24 hours)

Vector Fields, Line Integrals, Independence of Path and Conservative Vector Fields, Green's theorem, Surface Integrals, Applications of Surface Integrals; The Divergence Theorem, Stokes' Theorem.

[All theorems in this module should be discussed without proof].
The topics in this module can be found in chapter 15 [sections 15.1 to 15.8] of text [2].

Module 3: Abstract Algebra (30 Hours)

- Introduction and Examples, Binary Operations, Groups, Subgroups (only statements of theorems), Cyclic Groups (only statements of theorems except theorem 6.1).
- Groups of Permutations [exclude the section Cayley's Theorem].

- Rings and Fields [exclude the section Homomorphisms and Isomorphisms].

The topics in this module can be found in chapter I [sections 1,2,4,5,6], chapter II [section 8] and chapter IV [section 18] text [3].

Text [1] : B.S. Grewal, Higher Engineering Mathematics, 42nd Edition, Khanna Publishers.

Text [2]: Howard Anton, Irl Bivens, Stephen Davis. Calculus, 10th Edition, John Wiley & Sons.

Text [3]: John B. Fraleigh, A First Course in Abstract Algebra, Seventh Edition, Pearson.

References

I) K. F. Riley, M. P. Hobson, S.J. Bence. Mathematical Methods for Physics and Engineering, 3rd Edition, Cambridge University Press.

II) Mary. L. Boas. Mathematics Methods in the Physical Sciences, 3rd Edition, Wiley.

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

IV) Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley-India.

V) David M Bishop, Group theory and Chemistry, Dover Publications.

VI) J.A. Gallian, Contemporary Abstract Algebra, Narosa Publications.

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 1661	Elective Course	3	2	20	80	100
	MM 1645	Programming with 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 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*, 10^{th} Edition, John Wiley & Sons.

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

Text 3 Thomas Koshy, *Elementary Number Theory with Applications*, 2^{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.

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-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.

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 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 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/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*, 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*, 10^{th} 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*, 2nd 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.

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, 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 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*, 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.

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 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 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 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 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*, 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.

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, 5$^{\text{th}}$ 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, 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

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 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 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 LaTeX (6 Hours)

What is 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 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

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 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 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 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 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, 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.

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, 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 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

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 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 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/

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)