2023 Math

File Ref.No.33203/Ac A V/2022/UOK

UNIVERSITY OF KERALA

(Abstract)

Scheme and Syllabus of First Degree Programme in Mathematics revised w.e.f 2018 admission onwards - Corrected Syllabi of Core Courses in 5th and 6th Semesters applicable to 2021 and 2022 admission onwards- Approved-Orders-issued.

Ac A V

6842/2023/UOK

Dated: 01.08.2023

Read:-1.U.O No.AcAV/1/Mathematics/2018 dated 20.06.2018.

2.Minutes of the Annual meeting of Board of Studies in Mathematics (UG) held on 30/11/2022

3.Item No.IV(N) of the Minutes of the meeting of the Faculty of Science held on 02/03/2023.

4.Item No.(II)V of the Minutes of the meeting of the Academic Council held on 25/05/2023.

5. Email dated 29/10/2022 from the Chairman, BoS in Mathematics (UG)

6.Email dated 15/07/2023 from the Dean, Faculty of Science.

ORDER

The Scheme and Syllabus for First Degree Programme in Mathematics under CBCS system was revised w.e.f 2018 admissions vide U.O read as (1) above.

The Academic Council vide paper read as (4) above, resolved to approve the corrected syllabi of the following core courses in the V and VI Semesters of First Degree Programme in Mathematics (2018 admission onwards) as recommended by the Board of Studies in Mathematics (UG) and as endorsed by the Faculty of Science vide paper read as (2) and (3) above.

a)MM 1542- Complex Analysis I

b)MM 1642- Complex Analysis II

c)MM 1543- Abstract Algebra (Group Theory)

d)MM 1644- Linear Algebra.

Sanction has been accorded by the Vice Chancellor that the corrected syllabi of the above said courses be made applicable to 2021 and 2022 admissions, as recommended by the Chairman, Board of Studies in Mathematics (UG) and as endorsed by the Dean, Faculty of Science vide paper read as (5) and (6) above.

Orders are issued accordingly.

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Dhanuvachapuram

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 (30 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 (17 hours)

Elementary Functions: Polynomials and rational Functions (Proof of the theorem on partial fraction decomposition need not be discussed), The Exponential, Trigonometric, The Logarithmic Function, Complex Powers and Inverse Trigonometric Functions. (Hyperbolic Functions in section 3.2 need not be discussed)

The topics to be discussed in this module can be found in chapter 3, sections 3.1, 3.2, 3.3,of text [1] *below.*

Module III (25 hour)

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 and proof of Theorem 6 and Theorem 7 in section 4.3 need not be discussed),

The topics to be discussed in this module can be found in chapter 4, sections 4.1, 4.2, 4.3 and 4.4a 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**

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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, 2011

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

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Semester VI

COMPLEX ANALYSIS – II

CODE: MM 1642

Instructional hours per week: 4

No.of credits: 3

Course Outcomes

1. **Learn the well-known Cauchy's Integral Theorem.**
2. **Learn the Cauchy's Integral formula**
3. **Learn Taylor Series and Laurent series representations of analytic functions.**
4. **Learn the Residue Theory of Complex functions.**

Module-I

(20 Hours)

Cauchy's Integral Formula and Its Consequences, Bounds of Analytic Functions

The topics to be discussed in this module can be found in chapter 5, sections 4.5 and 4.6 of text [1] *below.*

Module-II

(20 Hours)

Series Representations for Analytic Functions: Sequences and Series, Taylor Series (proof need not be discussed), Power Series, Mathematical Theory of Convergence, Laurent series (proof need not be discussed), 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 III

(32 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.*

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, 2011

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

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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 of 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 (36 Hours)

In this module we prove one of the most important results in group theory which is the Lagrange'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 concept of group homomorphisms should be defined with sufficient number of examples. Also prove first isomorphism theorem.

The topics to be discussed in this module can be found in chapter 7, 9 and 10 of text [1] below.

Prescribed Text

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

References

1 — D. S. Dummit, R. M. Foote, *Abstract Algebra*, Third Edition, Wiley.

2 — I. N. Herstein, *Topics in Algebra*, Second Edition, Wiley.

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 interpretation of linear equations, following topics should be discussed: various operations on column vectors, technique of Gaussian elimination, operations in- volving 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 $\mathbf{R}^n$, 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 2.5 on graphs and networks may be omitted.*

Module-III (32 hours)

This module is intended for making the idea and concepts of determinants stronger. Its properties like what happens when rows are interchanged, linearity 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.
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.
The topics to be discussed in this module can be found in chapter 4 and chapter 5 (Sections 5.1, 5.2 and section 5.3 up to Fibonacci Numbers) of text [1] *below. Markov Matrices and Positive Matrices and Applications in Economics in section 5.3, section 5.4, section 5.5 and section 5.6 may be omitted*

Texts

Text -1 - Gilbert Strang, *Linear Algebra and Its Applications*, 4th Edition, Cengage Learn- ing

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 Edi- tion, Springer

Ref. 3 - T S Blyth, E F Robertson: ***Linear Algebra***, Springer, Second Edition. Ref. 4 - David C Lay: ***Linear Algebra***, Pearson, 2014

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

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UNIVERSITY OF KERALA

(Abstract)

First Degree Programme in Mathematics under CBCS System- Scheme and Syllabus revised with effect from 2023 admissions- Approved- Orders issued

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Ac A V

5387/2023/UOK

Dated: 23.06.2023

Read:-1.U.O No.AcAV/1/Mathematics/2018 dated 20.06.2018.

2.Minutes of the meeting of Board of Studies in Mathematics held on 22.03.2023.

3.Email dated 25.03.2023 from the Dean, Faculty of Science.

4.Item No.16 of the Minutes of the meeting of the Academic Council held on 25.05.2023.

ORDER

The Scheme and Syllabus for First Degree Programme in Mathematics under CBCS system was revised w.e.f 2018 admissions vide U.O read as (1) above.

The Academic Council vide paper read as (4) above, resolved to approve the revised Scheme and Syllabus for First Degree Programme in Mathematics under CBCS system, to be implemented with effect from 2023 admissions, as recommended by the Board of Studies in Mathematics (UG) held on 22/03/2023 and as endorsed by the Dean, Faculty of Science vide paper read as (2) and (3) above.

The Scheme and Syllabus is available in the University website.
Orders are issued accordingly.

MAYA DEVI C.B

DEPUTY REGISTRAR
For REGISTRAR

To

1.PS to VC/PVC
2. PA to Registrar/CE
3. The Dean, Faculty of Science
4. The Chairman, Board of Studies in Mathematics (UG).
5. The Principals of colleges offering First Degree Programme .
6. The Director, Computer Centre
7. JR (CBCS)
8. DR(CBCS)
9. AR (EB)/ CBCS/ES/IT cell Exams

10.CBCS sections/ ES Sections/EB sections
11. PRO/Enquiry
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Principal
V.T.M.N.S.S

The document is digitally approved. Hence signature is not needed.

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*, 10^{th} 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*, 9^{th} Edition, Addison-Weseley Publishing Company.

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

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

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*, 10$^{\text{th}}$ 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*, 4th Edition, John Wiley & Sons.

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

References

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

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

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

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

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

Semester V

Complex Analysis - I

Code: MM 1542 — Instructional hours per week: 4

No.of credits: 3

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

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

CO2 Understand the limits, continuity and 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, 2^{nd} Edition, Springer.

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

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

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

Semester V

Operations Research (Open Course)

Code: MM 1551.1 Instructional hours per week: 3

No. of credits: 2

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

CO1 Find the solutions of LPP using graphical method.

CO2 Solve transportation network problems and assignment problems.

CO3 Able to solve two person games.

CO4 Acquire clear cut knowledge in both theory and application.

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

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

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

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

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

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

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

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

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

Text

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

References

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

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

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

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

Semester V

Business Mathematics (Open Course)

Code: MM 1551.2 Instructional hours per week: 3

No. of credits: 2

Course Outcomes:

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

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

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

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

Module I - Basic Mathematics of Finance (18 Hours)

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

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

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

Module III - Index Numbers (18 Hours)

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

Text

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

References

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

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

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

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

Semester V

Basic Mathematics (Open Course)

Code: MM 1551.3 Instructional hours per week: 3

No. of credits: 2

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

Course Outcomes:

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

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

CO3 Getting exposed to basic statistical tools.

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

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

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

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

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

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

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

Texts

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

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

Reference

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

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, 10th Edition, 2018

References

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

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

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

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

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

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

Semester VI

Graph Theory (Elective)

Code: MM 1661.1 Instructional hours per week: 3

No. of credits: 2

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

Course Outcomes:

CO1 To define and understand the fundamental concepts of graph theory

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

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

Module I (27 Hours)

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

Paths and cycles: Connectivity - walks, paths and trials, disconnecting set, cutsets, 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

Fractal Geometry (Elective)

Code: MM 1661.2 Instructional hours per week: 3

No. of Credits 2

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

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

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

CO2 Construct and analyse a wide range of fractals.

Module I (27 Hours)

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

Module II (27 Hours)

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

functions-the Mandelbrot set, Julia sets of quadratic functions

Text

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

References

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

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

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

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

Semester VI

Numerical Methods (Elective)

Code: MM 1661.3 Instructional hours per week: 3

No. of Credits 2

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

CO1 Calculate errors in numerical calculations

CO2 Find numerical solutions of Algebraic and Transcendental Equations

CO3 Apply numerical methods to find differentiation and integration

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

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

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

Module II – Interpolation (18 Hours)

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

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

Module III – Numerical Differentiation and Integration (18 Hours)

The following are the main topics in this module:
Numerical differentiation-Errors in numerical differentiation, differentiation formulae with function values, maximum and minimum values of a

tabulated function, Numerical integration-Trapezoidal rule, Simpson's 1/3-rule, Simpson's 1/8-rule, Boole's and Weddle's rule, Romberg integration, Newton-Cotes formulae, Euler-Maclaurin formula.

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

Text

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

References

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

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

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

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

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

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

Semester VI

Programming with Python

Code: MM 1645 — Laboratory hours per week: 3

No. of credits: 4

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

CO1 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)

First Degree Programme in

Computer Applications (BCA)

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

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

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

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

PSO2 Recognize and appreciate the connections between theories and applications

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

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

Semester I

Mathematics I

Code: MM1131.9 Instructional hours per week: 4

No. of Credits 3

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

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

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

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

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

Module I (18 Hours)

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

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

Module II (18 Hours)

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

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

Module III (18 Hours)

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

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

Module IV (18 Hours)

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

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

Texts

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

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

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

References

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	1
CO2	2	2	2	2
CO3	2	2	2	1
CO4	3	3	2	2

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

Semester II

Mathematics II

Code: MM1231.9 Instructional hours per week: 4

No. of Credits 3

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

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

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

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

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

Module I (18 Hours)

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

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

Module II (18 Hours)

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

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

Module III (18 Hours)

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

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

Module IV (18 Hours)

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

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

Text

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	0
CO2	2	2	2	0
CO3	3	3	2	1
CO4	3	3	3	3

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

First Degree Programme in

Chemistry and Industrial Chemistry

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

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

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

PSO1 To provide strong foundation in Mathematics

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

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

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

Semester I

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

Code: MM 1131.7 Instructional hours per week: 5

No. of Credits 3

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

CO1 Compute the limits and derivatives.

CO2 Explain the concept rate of change.

CO3 Analyse function behavior.

CO4 Understand basic concepts of complex numbers.

Module I - Limits and continuity (24 Hours)

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

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

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

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

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

Module III - Applications of Derivatives (24 Hours)

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

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

Module IV - Complex numbers (18 Hours)

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

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

Texts

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

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

References

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	0
CO2	3	3	1	1
CO3	3	3	2	1
CO4	3	2	0	0

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

Semester II

Mathematics II
(Integral Calculus of One variable)

Code: MM 1231.7 Instructional hours per week: 5

No. of Credits 3

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

CO1 Explain the relationship between area and integral.

CO2 Compute integrals.

CO3 Compute area and volume using integration.

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

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

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

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

Module II - Applications of Integration (24 Hours)

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

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

Module III - Foundations of coordinate geometry (24 Hours)

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

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

Module IV - Special Functions (18 Hours)

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

Sections 11.1 to 11.7 of text [2].

Texts

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

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	3	0	0
CO2	3	2	0	0
CO3	3	2	1	3
CO4	3	3	0	0

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

Semester III

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

Code: MM 1331.7 Instructional hours per week: 5

No. of Credits 4

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

CO1 Describe a first order differential equation and solve it.

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

CO3 Understand linear transformation and eigen values.

CO4 Write the Fourier series of a periodic function.

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

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

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

Chapter11 of text [1].

Module II - System of linear Equations (24 Hours)

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

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

Module III - Fourier Series (24 Hours)

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

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

Module IV - Theory of Equations (18 Hours)

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

These topics can be found in text [3].

Texts

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

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

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3
CO2	3	3	2	0
CO3	3	3	1	0
CO4	3	3	1	2
CO5	3	3	2	0

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

Semester IV

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

Code: MM 1431.7 Instructional hours per week: 5

No. of Credits 4

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

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

CO2 Understand and apply basic operations among vectors.

CO3 Apply vector operators on scalar and vector point functions.

CO4 Apply Laplace transform on different functions.

Module I - Abstract Algebra (24 Hours)

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

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

Module II - Vector Algebra (18 Hours)

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

Sections: 3.1 to 3.10, text [1]

Module III - Vector Calculus (24 Hours)

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

Sections 8.1 to 8.11, text [1].

Module IV - Laplace Transforms (24 Hours)

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

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

Texts

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

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	0
CO2	3	3	1	0
CO3	3	3	0	0
CO4	3	3	0	3

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

First Degree Programme in

Physics and Computer Applications

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

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

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

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

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

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

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

PSO5 To become familiar with modern Mathematics

Semester I

Mathematics I

(Differential Calculus of One variable and Special functions)

Code: MM 1131.6 Instructional hours per week: 5

No. of Credits 4

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

CO1 Compute the limits and derivatives.

CO2 Explain the concept rate of change.

CO3 Analyse function behavior.

CO4 Understand basic concepts of some special functions.

Module I - Limits and continuity (24 Hours)

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

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

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

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

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

Module III - Applications of Derivatives (24 Hours)

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

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

Module IV - Special Functions (18 Hours)

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

Sections 11.1 to 11.7 of text [2].

Texts

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

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	3
CO2	3	3	2	3	3
CO3	3	3	3	2	3
CO4	3	3	2	2	3

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

Semester II

Mathematics II

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

Code: MM 1231.6 Instructional hours per week: 5

No. of Credits 4

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

CO1 Explain the relationship between area and integral.

CO2 Compute integrals.

CO3 Compute area and volume using integration.

CO4 Understand basic concepts of co ordinate geometry.

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

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

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

Module II - Applications of Integration (24 Hours)

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

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

Module III - Foundations of coordinate geometry (24 Hours)

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

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

Module IV - Complex numbers (18 Hours)

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

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

Texts

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

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	3
CO2	3	2	2	3	3
CO3	3	3	3	3	2
CO4	3	2	1	2	2

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

Semester III

Mathematics III

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

Code: MM 1331.6 Instructional hours per week: 5

No. of Credits 4

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

CO1 Describe a first order differential equation and solve it.

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

CO3 Understand some algebraic concepts.

CO4 Understand and apply the concept Laplace transform.

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

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

Sections : Chapter 11 of text [1].

Module II - System of linear Equations (18 Hours)

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

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

Module III - Abstract Algebra (24 Hours)

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

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

Module IV - Laplace Transforms (24 Hours)

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

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

Texts

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

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

References

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

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

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

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2
CO2	3	2	2	2	3
CO3	3	2	2	2	3
CO4	3	3	2	3	3

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

Semester IV

Mathematics IV

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

Code: MM 1431.6 Instructional hours per week: 5

No. of Credits 4

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

CO1 Analyse Fourier Series.

CO2 Understand and apply basic operations among vectors.

CO3 Apply vector operators on scalar and vector point functions.

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

Module I - Fourier Series (24 Hours)

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

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

Module II - Vector Algebra (18 Hours)

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

Sections: 3.1 to 3.10, text [1]

Module III - Vector Calculus (24 Hours)

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

Sections 8.1 to 8.11, text [1].

Module IV - Theory of Equations (24 Hours)

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

These topics can be found in text [3].

Texts

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

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

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

References

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

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

COs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	3
CO2	3	2	2	2	2
CO3	3	3	2	3	2
CO4	3	3	2	3	2

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

First Degree Programme in

Computer Science

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

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

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

PSO1 To provide sufficient knowledge and skills in mathematics

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

PSO3 Assimilate various graph theoretic concepts and familiarize with their applications

PSO4 Demonstrate proficiency in writing proofs

Semester I

Mathematics I

Code: MM 1131.10 Instructional hours per week: 4

No. of Credits 3

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

CO1 To familiarize participants with the scope and applications of Calculus

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

CO3 Describe Linear Algebra and its applications

Module I - Differentiation and its Applications (18 Hours)

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

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

Module II- Linear Algebra (18 Hours)

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

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

Module III - Graph theory (18 Hours)

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

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

Module IV - Number Theory (18 Hours)

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

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

References

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

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

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	3	0	0
CO2	3	3	3	2
CO3	3	3	2	1

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

Semester II

Mathematics II

Code: MM 1231.10 Instructional hours per week: 4

No. of Credits 3

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

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

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

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

Module I - Mathematical Logic (18 Hours)

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

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

Module II - Predicate Logic (18 Hours)

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

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

Module III - Set Theory (18 Hours)

Partition of Set: POSET - HASSE diagrams for partial ordering - lub, glb.

Lattices: Definition and Examples, principle of duality, Properties - Idempotency, commutativity, associativity, absorption (sub lattices excluded).
Group Theory: Definition, Examples, Order of a Group and its elements.

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

Module IV - Coding Theory and Combinatorics (18 Hours)

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

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

References

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

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2
CO2	3	3	2	2
CO3	3	3	2	1

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

First Degree Programme in

Electronics

SYLLABUS

Complementary Course in Mathematics

For 2023 admission onwards

SCHEME AND STRUCTURE OF THE COURSE

Sem	Course Code	Course Title	Instructional Hours per Week	Credit	Maximum Marks		
					CA	ESA	Total
I	MM 1131.8	Calculus with Applications - I	4	3	20	80	100
II	MM 1231.8	Calculus with Applications - II	4	3	20	80	100
III	MM 1331.8	Calculus and Linear Algebra	3	3	20	80	100

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

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

PSO2 Recognize and appreciate the connections between theories and applications

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

PSO4 Formulate and analyze mathematical models of real life situations

Semester I

Mathematics I

Calculus with Applications - I

Code: MM 1131.8 Instructional hours per week: 4

No. of Credits 3

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

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

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

Module I - Differentiation with Applications (18 Hours)

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

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

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

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

Module II - Integration with Applications (18 Hours)

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

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

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

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

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

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

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

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

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

References

Ref. 1 H Anton, I Bivens, S Davis, *Calculus*, 10$^{\text{th}}$ Edition, John Wiley and Sons.

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

Ref. 3 George B Arfken, Hans J Weber, Frank E Harris, *Mathematical Methods for Physicists*, 7$^{\text{th}}$ Edition, Academic Press

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3
CO2	3	2	3	3

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

Semester II

Mathematics III

Calculus with Applications - II

Code: MM 1231.8 Instructional hours per week: 4

No. of Credits 3

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

CO1 To acquaint students with vector algebra

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

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

CO4 To develop knowledge and skill in vector calculus.

Module I - Vector Algebra (18 Hours)

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

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

Module II - Partial Differentiation (18 Hours)

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

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

Module III - Multiple Integrals (18 Hours)

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

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

Module IV - Vector Calculus (18 Hours)

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

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

Texts

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

References

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

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

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

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

COs	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	1
CO2	3	2	3	2
CO3	3	3	3	3
CO4	3	2	3	2

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

Semester III

Mathematics III

Calculus and Linear Algebra

Code: MM 1331.8 Instructional hours per week: 3

No. of Credits 3

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

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

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

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

Module I - Mathematical Logic (18 Hours)

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

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

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

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

2022
Statistics

File Ref.No.21992/Ac A V/2022/UOK

UNIVERSITY OF KERALA

(Abstract)

Scheme and Syllabus for First Degree Programme in Statistics and Complementary courses in Statistics for First Degree Programme in Mathematics, Physics, Geography, Economics and Psychology under CBCS System- revised with effect from 2022 admissions- Approved- Orders issued.

Ac A V

4284/2022/UOK Dated: 26.05.2022

Read:-1.UO No.Ac.AV/1/Statistics(Compl.Courses) 2016 dated 10.11.2016

2.U.O No.AcAV/1/Statistics/2018 dated 20.06.2018.

3. Minutes of the Additional Meeting of the Board of Studies in Statistics held on 28.02.2022.

4. Item No.IV (V 1) of the Minutes of the Annual meeting of the Faculty of Science held on 17.03.2022.

5. Item No.II (V) of the Minutes of the meeting of the Academic Council held on 01.04.2022.

ORDER

The Scheme and Syllabus of Complementary courses in Statistics for First Degree Programme in Physics, Geography, Economics and Psychology had been revised w.e.f 2017 admissions vide U.O read as (1) above & Scheme and Syllabus for First Degree Programme in Statistics under CBCS system and Complementary courses in Statistics for Mathematics had been revised w.e.f 2018 admissions vide U.O read as (2) above.

The Additional Meeting of the Board of Studies in Statistics (Pass) vide paper read as (3) above, recommended the revised Scheme and Syllabus for First Degree Programme in Statistics and Complementary courses in Statistics for First Degree Programme in Mathematics, Physics, Geography, Economics and Psychology under CBCS system, to be implemented with effect from 2022 admissions.

The Annual meeting of the Faculty of Science vide paper read as (4) above, endorsed the recommendations of the Board of Studies in Statistics (Pass).

The Academic Council vide paper read as (5) above, resolved to approve the revised Scheme and Syllabus for First Degree Programme in Statistics and Complementary courses in Statistics for First Degree Programme in Mathematics, Physics, Geography, Economics and Psychology under CBCS system, as recommended by the Board of Studies in Statistics (Pass) and as endorsed by the Faculty of Science.

The Scheme and Syllabus is available in the University website.

Orders are issued accordingly.

MAYADEVI C B

DEPUTY REGISTRAR

For REGISTRAR

To

1. PS to VC/PVC
2. PA to Registrar/CE
3. The Dean, Faculty of Science
4. The Chairman, Board of Studies in Statistics
5. The Principals of colleges offering First Degree Programme
6. The Director, Computer Centre
7. JR (CBCS)
8. DR(CBCS)
9. AR (EB)/ CBCS/IT cell Exams
10. CBCS sections/ EB sections
11. PRO/Enquiry
12. Stock File/File Copy

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Section Officer

Principal
V.T.M.N.S.S. College
Dhanuvachapuram

UNIVERSITY OF KERALA

SYLLABUS IN OUTCOME-BASED EDUCATION MODE

FOR

FIRST DEGREE PROGRAMME IN STATISTICS

(BSc)

UNDER CHOICE BASED

CREDIT AND SEMESTER SYSTEM

(CBCSS)

2022 ADMISSION ONWARDS

UNIVERSITY OF KERALA

FIRST DEGREE PROGRAMME IN STATISTICS

CHOICE BASED CREDIT AND SEMESTER SYSTEM

EFECTIVE FROM 2022 ADMISSIONS

(Revised)

Aims and Objectives of the Programme

Aims:

The aim of the programme is to provide a solid foundation in all aspects of Statistics and to show a broad spectrum of modern trends in Statistics and to develop experimental, computational and application skills of students. The syllabus is framed in such a way that it bridges the gap between the higher secondary and post graduate levels of Statistics by providing a more complete and logical framework in almost all areas of basic Statistics. The new, updated syllabus is in accordance with the paradigm of outcome-based education (OBE). The programme also aims at:

(i) providing education in Statistics of the highest quality at the undergraduate level and produce graduates of the calibre sought by industries and public service as well as academic teachers and researchers of the future.

(ii) attracting outstanding students from all backgrounds.

(iii) providing an intellectually stimulating environment in which the students have the opportunity to develop their skills and enthusiasms to the best of their potential.

(iv) maintaining the highest academic standards in undergraduate teaching.

(v) imparting the skills required to gather information from resources and use them.

UNIVERSITY OF KERALA

First Degree Programme under CBCSS

Scheme and Syllabus (Outcome Based Education) of Complementary STATISTICS for B. Sc. Mathematics Core

(with effect from 2022 Admission)

The syllabus is designed with an aim to equip the students with the major concepts and methods of Statistics along with the tools required to implement them in practical situations. The syllabus is prepared in accordance with the Outcome Based Education (OBE) paradigm. The curriculum is dispensed using a combination of classroom teaching, discussions, presentations, practicals, assignments, class tests etc. The syllabus has been designed to stimulate the interest of the students in Statistics and prepared in order to equip the students with a potential to contribute to the academic and industrial requirements of the society. Emphasis is given to understand the basic concepts and data analysis tools. There are practical sessions in each semester. Numerical problems solving using scientific calculators is also included in the End Semester Examination (ESE) of Courses in the semesters I, II, III & IV. Statistical computation with R is introduced which would help the students for analyzing data by making optimum usage of time and resources. For practical classes, there shall be one faculty member in charge of every 16 students (based on sanctioned strength), in accordance with the University regulations. There will be one ESE of 2 hours duration on practical using R in Semester IV.

It is mandatory to submit a duly certified Record book of practical sheets, consisting of printout of numerical problems, their R codes and results, for appearing for ESE of practical course. ESE of the practical course with a maximum of 60 marks will be held under the supervision of External Examiners duly appointed by the University. The External Examiner will also evaluate the Record books of practical work done at Lab for 20 marks.

Course Structure:

Semester	Course Code	Title of the course	Hours/ week		No. of credits	Total Hrs/ Semester	ESE Duration	Weightage In %	
			L	P				CE	ESE
I	ST 1131.1	Descriptive Statistics and Bivariate Analysis	2	2	2	72	3 hrs	20	80
II	ST 1231.1	Probability and Random Variables	2	2	2	72	3 hrs	20	80
III	ST 1331.1	Statistical Distributions	3	2	3	90	3 hrs	20	80
IV	ST 1431.1	Statistical Inference	3	2	3	90	3 hrs	20	80
	ST 1432.1	Practical using R			4		2 hrs	20	80

L – Lecture hour; P- Practical (Lab) hour

Semester - I

Course - I

ST 1131.1: Descriptive Statistics and Bivariate Analysis

Credits: 2

Hours/week: 4 (L-2, P-2)

Course Outcomes

On completion of the course, students will be able to:

CO.1: Explain the concepts of statistical surveys, sampling, census and various sampling methods like simple random sampling, systematic sampling, and stratified sampling.

CO.2: Design questionnaires and carry out surveys.

CO.3: Collect and present raw data using frequency tables as well as appropriate graphs.

CO.4: Summarize data using various measures of central tendency, dispersion, skewness and kurtosis.

CO.5: Explain the concepts of scatter diagram, correlation and calculate the correlation between two variables.

CO.6: Explain the concept of regression, fit various regression equations to given data sets and predict values of response variables.

CO.7: Explain various concepts associated with the two regression lines and identify the regression lines for given data sets.

CO.8: Practicals: Use R built in functions to solve numerical problems associated with topics covered in Modules I and II.

Module Outcomes

Sl. No:	Outcomes		Taxonomy Level
	On completion of each module, students should be able to:		
MODULE 1 Part B	MO 1.1	Define various scales of data	Remember
	MO 1.2	Distinguish between primary and secondary data	Understand
	MO 1.3	Articulate concepts of statistical surveys, sampling, and census	Understand
	MO 1.4	Define various methods of sampling	Remember
	MO 1.5	Design a questionnaire and carry out a simple survey	Understand
	MO 1.6	Construct various frequency tables	Create
MODULE 2	MO 2.1	Calculate the various measures of central tendency, dispersion, skewness and kurtosis.	Apply

	MO 2.2	Compare the merits and demerits of various measures of central tendency and dispersion.	Understand
	MO 2.3	Describe certain theoretical properties of the measures of central tendency, measures of dispersion and moments	Understand
	MO 2.4	Compare various data sets based on measures of central tendency, dispersion, skewness and kurtosis.	Evaluate
MODULE 3	MO 3.1	Explain concepts of scatter diagram, correlation and regression.	Understand
	MO 3.2	Apply principle of least squares to fit various curves	Apply
	MO 3.3	Fit various curves to data sets	Apply
MODULE 4	MO 4.1	Construct regression lines for data sets.	Apply
	MO 4.2	Identify regression lines	Analyze
	MO 4.3	Calculate angle between lines, point of intersection etc.	Analyze
	MO 4.4	Calculate Pearson's coefficient of correlation, Spearman's rank correlation coefficient and interpret the results.	Evaluate
	MO 4.5	Coefficient of determination and coefficient of alienation	Remember
MODULE 5 (Only for Practical Exam)	MO 5.1	Use built in R functions: (i) For representing data using diagrams and graphs. (ii) For calculating the various measures of descriptive statistics	Apply

Course Content

Module I:

Part A: Introduction (Not for Examination Purpose): Definition and significance of Statistics, Limitations and misuse of Statistics, Official Statistical system of India. Types of Data: Concepts of primary data and secondary data, population, and sample; Classification of data based on geographic, chronological, qualitative and quantitative characteristics.

Part B: Collection and Presentation of Data: Scales of data-nominal, ordinal, interval and ratio. Methods of collection of primary data–Preparation of questionnaires / schedules. Secondary data – major sources and limitations; Census and Sample Surveys; Methods of sampling ***(concepts only):*** Probability and non-probability sampling, simple random sampling with replacement (SRSWR) & simple random sampling without replacement (SRSWOR), Systematic sampling and Stratified sampling; sampling and non-sampling errors; Classification and tabulation - Construction of tables with one or more factors of classification, frequency distributions, relative and cumulative frequency distributions.

Module II:

Summarization of Data: Central tendency- mean, median, mode, geometric mean, harmonic mean; properties of arithmetic mean and median; Relationship between AM, GM and HM; Absolute and relative measures of dispersion: Range, quartile deviation, mean deviation and standard deviation; Properties of mean deviation, standard deviation, combined mean and combined standard deviation;

coefficient of variation; moments - raw and central moments; relationship between raw and central moments; effect of change of origin and scale; skewness, kurtosis and their measures.

Module III:

Bivariate data: Scatter diagram, fitting of curves- Principle of least squares, fitting of straight line $y = ax + b$, fitting of curves: $y = ax^2 + bx + c, a \neq 0$, $y = ab^x$, $y = ax^b$, $y = ae^{bx}$.

Module IV:

Karl Pearson's coefficient of correlation, Spearman's rank correlation coefficient, regression lines and prediction, coefficient of determination and coefficient of alienation (definition only)

Module V: (only for Practical Exam)

Basics of R (as given in Practical Sheet - 1); Practical based on Modules I & II – Data analysis: presentation of data – charts and diagrams, calculation of descriptive statistics, moments, measures of skewness and kurtosis.

References:

1. Agarwal, B.L. (2006). *Basic Statistics*. 4th Edition, New Age international (P) Ltd., New Delhi.
2. Gupta S. P. (2004). *Statistical Methods*. Sultan Chand & Sons, New Delhi.
3. Gupta, S. C., and Kapoor, V. K. (1994). *Fundamental of Mathematical Statistics*. Sultan Chand & Sons, New Delhi.
4. Kenny J. F (1947). *Mathematics of Statistics Part One*. 2nd Edition, D. Van Nostard Company, New Delhi-1.
5. Kenny J. F & Keeping E. S (1964). *Mathematics of Statistics –Part Two*. 2nd Edition, D. Van Nostard Company, New Delhi-1.
6. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.

Semester – II

Course - II

ST 1231.1: Probability and Random Variables

Credits: 2

Hours/week: 4 (L-2, P-2)

Course outcomes

On completion of the course, the students should be able to:

CO.1: Distinguish between random and non-random experiments.
CO.2: Evaluate the probabilities of events using classical, statistical and axiomatic approaches.
CO.3: Identify independent events; calculate conditional probability and application of Bayes' theorem.
CO.4: Distinguish between discrete and continuous random variables with its probability distributions.
CO.5: Assess the independence of random variables.
CO.6: Calculate moment generating function and characteristic function.
CO.7: Determine the conditional mean and variance of a random variable.
CO.8: Evaluate the correlation between two random variables.
CO.9: Practical: Use R built in functions to solve numerical problems associated with topics covered in modules III and IV of ST 1131.1 (of Semester -I)

Module Outcomes

Sl. No:	Outcomes On completion of each module, students should be able to:		Taxonomy Level
MODULE 1	MO 1.1	Distinguish between Random and non-random experiments	Understand
	MO 1.2	Explain the concepts of sample space, types of events and algebra of events	Understand
	MO 1.3	Describe the probabilities of events using classical, statistical and axiomatic approaches.	Apply
	MO 1.4	Identify mutually exclusive and exhaustive events	Understand
	MO 1.5	Define equally likely events	Remember
MODULE 2	MO 2.1	Determine the conditional probability and apply multiplication theorem	Evaluate
	MO 2.2	Explain the concepts of independence of events	Analyze
	MO 2.3	Use Bayes' theorem to evaluate posterior probabilities	Apply
MODULE 3	MO 3.1	Explain the concept of random variables	Understand
	MO 3.2	Distinguish between the discrete and continuous random variables and find its probability distributions	Analyze
	MO 3.3	Evaluate marginal and conditional distributions of bivariate random variables	Evaluate
	MO 3.4	Check for the independence of random variables	Analyze
	MO 3.5	Apply the concepts of transformation of univariate random variables	Analyze
MODULE 4	MO 4.1	Explain the concepts of mathematical expectation and its properties.	Understand
	MO 4.2	Determine the mathematical expectation of a discrete and continuous random variable	Apply
	MO 4.3	Calculate the conditional mean and variance of bivariate distributions	Apply
	MO 4.4	Explain the basic concepts of moment generating function and characteristic function	Apply

	MO 4.5	Evaluate the covariance and correlation coefficient of two random variables.	Apply
MODULE 5 (only for Practical Exam)	MO 5.1	Use built in R functions to solve numerical problems corresponding to modules III and IV of ST 1131.1 of Sem-1	Apply

Course content

Module I:
Random experiments - sample space and sample point; Events-algebra of events, concepts of equally likely, mutually exclusive and exhaustive events.
Probability: Statistical regularity, classical approaches, Axiomatic approach, theorems in probability, probability space.

Module II:
Conditional probability, multiplication theorem, independence of two and three events, compound probability, Bayes' theorem and its applications.

Module III:
Random variables - discrete and continuous, probability mass function and probability density function, distribution function, joint distribution of two random variables, marginal and conditional distributions, independence, transformation of variables-one-to-one transformations - univariate case only.

Module IV:
Expectation of random variables and its properties, theorems on expectation of sums and product of independent random variables, conditional expectation, moments, moment generating function, characteristic function, their properties and uses; bivariate moments, Cauchy- Schwartz inequality and correlation coefficient.

Module V: Practical (Numerical Problems) based on Modules III & IV of ST 1131.1 (Sem.1) - Scatter diagram, curve fitting, measures of correlation, regression analysis.

References

1. Bhat B. R. (1985). *Modern Probability Theory*. New Age International (P) Ltd, New Delhi.
2. Gupta, S. C., and Kapoor,V. K. (1994). *Fundamentals of Mathematical Statistics*. Sultan Chand & Sons. New Delhi.
3. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.

4. Pitman, J. (1993). *Probability*. Narosa Publishing House, New Delhi.
5. Rao C. R. (1973). *Linear Statistical Inference and its Applications*. 2nd edition, Wiley, New York.
6. Rohatgi V. K. (1993). *An Introduction to Probability Theory and Mathematical Statistics*. Wiley Eastern, New Delhi.

Semester – III

Course - III

ST 1331.1: Statistical Distributions

Credits: 3

Hours/week: 5 (L-3, P-2)

Course Outcomes

On completion of the course, students will be able to:

CO.1: Define various discrete and continuous standard distributions and explain their theoretical properties.

CO.2: Solve numerical problems associated with discrete and continuous standard distributions.

CO.3: Fit binomial, Poisson and normal distributions to data sets and calculate theoretical frequencies.

CO.4: Explain the laws of large numbers and apply them to solve numerical problems

CO.5: Define sampling distributions (normal, chi-square, Students t and F) and solve elementary numerical problems.

CO.6: Practicals: Use built in functions of R to solve numerical problems on modules I, II & IV.

Module Outcomes

Sl. No:	Outcomes		Taxonomy Level
	On completion of each module, students should be able to:		
MODULE 1	MO 1.1	Explain discrete standard distributions and their practical applications.	Understand
	MO 1.2	Describe the theoretical properties of these distributions.	Understand
	MO 1.3	Solve numerical problems associated with these distributions.	Apply
	MO 1.4	Fit binomial and Poisson distributions to data sets and calculate theoretical frequencies.	Analyze
MODULE	MO 2.1	Define continuous standard distributions.	Understand

2	MO 2.2	Describe the theoretical properties of these distributions.	Understand
	MO 2.3	Solve numerical problems associated with these distributions.	Apply
	MO 2.4	Fit Normal distribution to data sets and calculate theoretical frequencies.	Analyze
MODULE 3	MO 3.1	Explain Chebycheff's inequality and laws of large numbers.	Understand
	MO 3.2	Derive Chebycheff's inequality and laws of large numbers.	Apply
	MO 3.3	Apply the laws of large numbers to solve numerical problems.	Analyze
MODULE 4	MO 4.1	Distinguish between parameter and statistic.	Understand
	MO 4.2	Define sampling distributions (normal, chi-square, t and F).	Remember
	MO 4.3	Derive distributions of sample mean and sample variance.	Understand
	MO 4.4	Solve numerical problems associated with these distributions using their respective table values.	Apply
	MO 4.5	State relations between the sampling distributions.	Remember
MODULE 5 (only for Practical Exam)	MO 5.1	Use built-in R functions to solve numerical problems associated with standard distributions and sampling distributions. (to the extent of the portions covered in the modules I, II and IV)	Apply

Course Content

Module I:
Standard Distributions (Discrete)- uniform, binomial, Poisson and geometric- moments, moment generating function, characteristic function, problems, additive property (binomial and Poisson), recurrence relation (binomial and Poisson), Poisson as a limiting form of binomial, memoryless property of geometric distribution; Fitting of binomial and Poisson distributions; hypergeometric distribution (definition, mean and variance only).

Module II:
Standard Distributions (Continuous)– uniform, exponential, and gamma - moment generating function, characteristic function, problems; memoryless property of exponential distribution; additive property of gamma distribution; beta distribution (I and II kinds)- moments, normal distribution- moments, moment generating function, characteristic function, problems, recurrence relation of central moments; convergence of binomial and Poisson to normal.

Module III:
Chebychev's inequality; Law of large numbers-BLLN, convergence in probability (definition only), WLLN; central limit theorem (Lindberg-Levy form) - statement and applications only.

Module IV:
Sampling distributions - Parameter and statistic, Sampling distributions- Distribution of mean of a sample taken from a normal population, chi-square - definition and properties, t and F distributions (definitions only) and statistics following these distributions, relation between normal, chi-square, t and F distributions.

Module V:

Numeric problems based on Modules I, II & IV – Discrete and continuous probability distributions and evaluation of probabilities, sampling distributions and their probability evaluation, random number generation.

References

1. Gupta S.C. and Kapoor V.K. (1980). *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons, New Delhi.
2. John E. Freund (1980). *Mathematical Statistics*. Prentice Hall of India, New Delhi.
3. Medhi J. (2005). *Statistical Methods-An Introductory Text*. New Age International (P) Ltd, New Delhi.
4. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
5. Rohatgi V. K. (1993). *An Introduction to Probability Theory & Mathematical Statistics.* Wiley Eastern, New Delhi.

Semester – IV

Course - IV

ST 1431.1: Statistical Inference

Credits: 3

Hours/week: 5 (L-3, P-2)

Course outcomes

On completion of the course, the students should be able to:

CO.1: Analyze a sample to draw valid inferences about the parameters of a statistical population.

CO.2: Explain the properties of estimators and solve numerical problems for the point and interval estimators of the parameters.

CO.3: Explain the concept of testing statistical hypotheses.

CO.4: Identify two types of errors, compute level of significance and power of a test.

CO.5: Conduct tests for hypothesis about the population mean and proportion using large samples.

CO.6: Conduct tests for hypothesis about the homogeneity and independence using chi-square statistics.

CO.7: Conduct tests for hypothesis about the mean and variance for normal population using small samples.

CO.8: Carry out and interpret ANOVA.

CO.9: Practical: Use R built-in functions to solve numerical problems associated with topics covered in various modules.

Module outcomes

Sl. No:	Outcomes		Taxonomy Level
	On completion of each module, students should be able to:		
MODULE 1	MO 1.1	Define point estimator of a parameter in a statistical population.	Remember
	MO 1.2	Illustrate whether an estimator satisfying unbiased and consistent.	Understand
	MO 1.3	Explain sufficiency and efficiency of an estimator.	Apply
	MO 1.4	Describe maximum likelihood estimator and moment estimator of a parameter.	Apply
	MO 1.5	Define confidence interval.	Remember
	MO 1.6	Construct confidence intervals for mean, variance and proportion in a population.	Apply
MODULE 2	MO 2.1	Explain the concept of statistical hypothesis.	Understand
	MO 2.2	Describe two types of errors in a statistical hypothesis.	Understand
	MO 2.3	Determine the level of significance and power of a test.	Apply
	MO 2.4	Explain Neyman- Pearson lemma.	Apply
MODULE 3	MO 3.1	Define large sample and small sample tests.	Remember
	MO 3.2	Describe the test procedure for mean and proportion (one and two sample cases) using large samples.	Apply
	MO 3.3	Examine the homogeneity and independence using chi-square tests	Apply
	MO 3.4	Explain paired t test.	Apply
	MO 3.5	Describe the test procedure for mean and variance (one and two sample cases) for normal population using small samples.	Apply
MODULE 4	MO 4.1	Explain the concept of Analysis of variance.	Understand
	MO 4.2	Explain the model and hypothesis of one way and two way classified data.	Understand
	MO 4.3	Construct ANOVA table and draw inferences from it.	Evaluate
MODULE 5 (only for Practical Exam)	MO 5.1	Use built-in R functions to solve numerical problems associated with Modules III & IV.	Apply

Course content

Module I:
Point estimation, desirable properties of estimators – unbiasedness, consistency, efficiency and sufficiency; Methods of estimation –Maximum likelihood method and method of moments; Interval estimation of mean, variance and proportion (single unknown parameter only).

Module II:
Testing of Hypothesis: statistical hypotheses, simple and composite hypotheses, two types of errors, significance level, p-value, power of a test, Neyman-Pearson lemma (statement only) and applications.

Module III:
Large sample tests – testing mean and proportion (one and two sample cases), chi-square test of goodness of fit, independence and homogeneity.
Small sample tests- Z-test for means; one sample test for mean of a normal population, equality of means of two independent normal populations, t-test for independent samples and paired samples, chi-square test for variance, F-test for equality of variances.

Module IV:
Design of Experiments- assumptions and principles, Analysis of Variance (ANOVA) of one way and two way classified data (Derivation of two– way model is not included).

Module V: Practical based on Modules III &IV – tests of hypotheses (as given in Practical Sheet – 11); one way and two way ANOVA.

References

1. Das M. N., Giri N. C. (2003). *Design and analysis of experiments*. New Age International (P) Ltd, New Delhi.
2. John E. Freund (1980). *Mathematical Statistics*. Prentice Hall of India, New Delhi.
3. Medhi J. (2005). *Statistical Methods-An Introductory Text*, New Age International (P) Ltd. New Delhi.
4. Paul G. Hoel, Sidney C. Port, Charles J. Stone (1971). *Introduction to Statistical Theory*. Universal Book stall, New Delhi.

Semester – IV

Course - V

ST 1432.1: Practical using R

Credits: 4

Any standard version of R in any operating system can be used. The Record book is mandatory to appear for the Practical examination. The Record book should contain following Practical sheets based on Module V of Courses ST1131.1 to ST 1431.1. Minimum number of questions covering all functions/methods given therein must be included in each practical sheet along with R code, their outputs, interpretation / conclusion.

Practical Sheet - 1: Data Types in R

Basics of vector, matrix and data frame, basic functions – c( ), sequence( ), scan( ), factor( ) table( ), and cut( ).

Minimum number of questions - 12

Practical Sheet - 2: Sampling and Frequency Tables.

Forming ungrouped and grouped frequency tables with raw data using table and cut functions. SRSWR and SRSWOR with sample( )

Minimum number of questions - 8

Practical Sheet - 3: Measures of Central Tendency

Descriptive measures: sum, sort, min, max, length, mean, median, mode (using sort and table), geometric mean, harmonic mean.

Minimum number of questions - 10

Practical Sheet - 4: Measures of Dispersion

Range, mean deviation, IQR, quartile deviation, sd, var, coefficient of variation, quantile, summary.

Minimum number of questions - 10

Practical Sheet - 5: Moments, Skewness and Kurtosis

Computation of raw, central moments, moment measures of skewness and kurtosis.

Minimum number of questions - 8

Practical Sheet - 6: Graphical Methods

Simple bar plot, multiple bar plot (side by side and subdivided), pie chart, histogram, scatter plot, plot function and lines function.

Minimum number of questions - 8

Practical Sheet - 7: Probability Distributions

Binomial, Poisson, normal, chi-square, t and F distributions – The **d**, **p**, **q** and **r** functions, the scale function, evaluation of probabilities using these functions.

Minimum number of questions - 10

Practical Sheet - 8: Fitting of Distributions

Fitting of binomial, Poisson and normal distributions.

Minimum number of questions - 3

Practical Sheet - 9: Correlation and Regression

Computation of covariance for a bivariate data using cov(), Pearson's and Spearman's correlation coefficient using cor(). Linear regression models: fitting using lm(), prediction from fitted model.

Minimum number of questions - 6

Practical Sheet - 10: Curve Fitting

Fitting of a straight line and $y = ax^2 + bx + c, a \neq 0$; $y = ae^{bx}$, $y = ab^x$ and $y = ax^b$, where a, b *and* c are real constants.

Minimum number of questions - 5

Practical Sheet - 11: Testing of Hypotheses

Testing of hypothesis: prop.test (one sample and two sample), t.test (one sample, two sample, and paired), chi squared tests (goodness of fit, and independence of attributes). F test for equality of variances.

Minimum number of questions - 8

Practical Sheet - 12: Analysis of Variance

Analysis of Variance: One way anova and two way anova with one observation per cell.

Minimum number of questions - 4

References:

1. Dalgaard, P.(2008). *Introductory Statistics with R*, Springer, New York.
2. Kerns, G J. (2010). *Introduction to Probability and Statistics using R.* ISBN-10 : 0557249791
3. Lander J. P. (2017). *R for everyone* 2/e. Addison-Wesley Professional, U. S.
4. Michael J. Crawley (2013). *The R Book*, 2/e, Wiley, New York.
5. Purohit, S. G., Deshmukh, S.R., & Gore, S. D. (2008). *Statistics using R*. Alpha Science International, United Kingdom.

Web Resources:

1. https://cran.r-project.org
2. https://cran.r-project.org/manuals.html
3. https://www.r-project.org/other-docs.html
4. https://journal r-project.org/
5. https://www.r-bloggers.com

2021 | Compl Math

File Ref.No.11691/Ac A V/2021/U

UNIVERSITY OF KERALA

(Abstract)

First Degree Programme in Mathematics under CBCS System -revised Scheme and Syllabi and text books of the Complementary Courses in Mathematics for the First Degree Programme in Physics, Chemistry, Statistics and Economics courses under CBCS System-w.e.f 2021 admissions-Approved-Orders Issued.

Ac A V

3499/2021/UOK Dated: 18.07.2021

Read:-1.U.O.No.Ac.AV/1/Mathematics/2018 dated 20.06.2018

2.Minutes of the additional meeting of the Board of Studies in Mathematics (Pass) held on 26.03.2021

3.Item.No.IX.i of the Minutes of the annual meeting of the Faculty of Science held on 30.03.2021

4.Item.No.II.(v) of the Minutes of the meeting of the Academic council held on 21.04.2021

ORDER

The Scheme and Syllabus of First Degree Programme in Mathematics (Core, Complementary, Foundation, Open and Elective courses) has been revised vide paper read as (1) above.

The additional meeting of the Board of Studies in Mathematics (Pass) vide paper read as (2) above, recommended the revised Syllabi and text books for the Complementary courses in Mathematics for the First Degree Programmes in Physics, Chemistry, Statistics and Economics under CBCS System (Physics MM 1131.1, MM 1231.1, MM 1331.1 & MM 1431.1, Chemistry-MM 1131.2, MM 1231.2, MM 1331.2 & MM 1431.2, Statistics- MM 1131.4, MM 1231.4, MM 1331.4, Economics- MM 1131.5, MM 1231.5, MM 1331.5 & MM 1431.5) and also decided to change the text books for the same.

The annual meeting of the Faculty of Science vide paper read as (3) above, recommended the Scheme, Syllabi and text books for the Complementary Courses in Mathematics for Physics, Chemistry, Statistics (I, II and III) and Economics under CBCS System, submitted by the Chairman, Board of Studies in Mathematics (Pass).

The Academic Council vide paper read as (4) above, resolved to approve the revised Scheme, Syllabi and text books for the Complementary Courses in Mathematics for Physics, Chemistry, Statistics (I, II and III semester) and Economics under CBCS System, to be implemented w.e.f 2021 admissions, as recommended by the Board of Studies in Mathematics (Pass) and as endorsed by the Faculty of Science.

The Scheme and Syllabi are available in the University Website.
Orders are issued accordingly.

SINDHU GEORGE

DEPUTY REGISTRAR
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To

1.PS to VC/PVC
2.PA to Registrar/CE
3.The Dean, Faculty of Science
4.The Chairman, Board of Studies in Mathematics (Pass)
5.The Principals of all affiliated colleges offering First Degree Programmes
6.The Director, Computer Centre
7.JR (CBCS/Academic)
8.DR (CBCS/EB)
9.AR(CBCS/B.SC/EB/IT cell Exams)
10.B.Sc /EB/IT cell exams
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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.

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'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 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

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.

[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 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

MM 1331.2 —(1/1)

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

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.

MM 1431.2 -(1/2)

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

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.

<u>**References**</u>

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.

mm 1131.4 —(1/2)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Statistics
Semester I
Mathematics I
(Differential Calculus)
Code: MM 1131.4

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. As this course is designed as a complementary course for students of B.Sc. Statistics, we may avoid all the proofs of theorems.

Module 1: Differential calculus of one variable (24 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 higher derivatives, 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 as in sections 6.1 and 6.2 (avoid results on integration). Definition Evaluation 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 (24 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. Rolles theorem and mean value theorem has to be discussed as in section 3.8. This section ends with LHopitals 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 (24 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 Laplaces 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]

Text

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 2

mm 1231.4 – (V1)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Statistics
Semester II
Mathematics II
(Integral calculus and sequences and series)
Code: MM 1231.4

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.A short section on sequences and series is also included. As this course is designed as a complementary course for students of B.Sc. Statistics, 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: 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 1331.4 — (V,)

University of Kerala
Complementary Course in Mathematics
for First Degree Programme in Statistics
Semester III
Mathematics III
(Fourier series, Numerical Methods and ODE)
Code: MM 1331.4

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

Module 1: Fourier Series (20 Hours)

Introduction, Eulers 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 : Numerical Solutions (35 Hours)

Numerical Solution of Equations :-Introduction, Solution ofAlgebraic 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), Newtons Interpolation Formulae, Lagranges Interpolation Formula.

Numerical Integration :-Numerical Integration, Trapezoidal Rule, Simpsons One-Third Rule, Simpsons Three-Eighth Rule, Weddles Rule.

Numerical Solution of Ordinary Differential Equations :-Taylors Series Method,Runge-Kutta Method, Predictor-Corrector Methods, Milnes Method

The topics in thismodule can be found in chapter 26 [sections26.1 to 26.9, 26.14 to 26.16] of the text

Module 3: Ordinary Differential Equations (35 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, Bernoullis Equation, Exact Differential Equations, Equations reducible to exact equations, Equations of the First Order and Higher Degree, Clairauts 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 13, sections 13.1, 13.3, 13.4, 13.5, 13.8 and 13.9 of text [1]

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 1131.5 —(1/1)

University of Kerala
Complimentary course in Mathematics for first degree programme in Economics
Semester I
Mathematics for Economics - I

Code : MM 1131.5

Instructional hours per week: 3

No.of Credits:2

Module 1: Theory of Sets

Finite and infinite sets, set operations- ordered pairs, cartesian products, Relations, Functional Relations and Functions.

Chapter 1: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6,1.7, 1.8, 1.9 and 1.14, 1.15,1.16, 1.17 of Text 1

Module 2: Equations

Equations and identities:- Linear quadratic equations, solutions of equations, solutions of quadratic equations, simultaneous equations, solutions of simultaneous equations, Applications in Economics. Functions and curves in Economics:- Demand functions and curves, total revenue curve, cost curves.

Chapter 3: 3.1 and Appendix to chapter 4 of Text 1

Text.1 Mehta Madnani, Mathematics for Economics,Sultan Chand and Sons Educational Publishers, New Delhi

References

1. Knut Sydsaeter and Peter Hammond with Arne Strom, Essential Mathematics for Economic Analysis, Fourth Edition, Pearson Education limited.

2. Allen.R.G.D, Mathematical Analysis for Economics, Mc Millan Press, London

3. Chiang.A.C, Fundamental Methods of Mathematical Economics, Mc Graw Hill, New Delhi.

MM 1231.5 — (1/1)

University of Kerala
Complimentary course in Mathematics for first degree programme in Economics
Semester II
Mathematics for Economics -II

Code : MM 1231.5

Instructional hours per week: 3

No.of Credits:3

Module 1: Differential Calculus: One variable

Differentiation: Basic definition, process of diffrentiation, Rules of differentiation, some standard results(without proof), Derivatives of higher order with simple problems involving polynomial functions (exept trigonometric and logarithmic functions).

Chapter 6: 6.3, 6.4, 6.5 of Text 1

Module 2: Differentiation II

Sign of the differential coefficients, Second derivative and nature of curve, maximum and minimum value of a function, order condition for maximum-minimum(extreme) values.
Applications of simple derivatives: Differential coefficient and elasticity of demand.

Chapter 6: 6.6,6.7, 6.8, 6.9 of Text 1

Chapter 7: 7.1 of Text 1

Text.1 Mehta Madnani, Mathematics for Economics,Sultan Chand and Sons Educational Publishers, New Delhi

References

1. Knut Sydsaeter and Peter Hammond with Arne Strom, Essential Mathematics for Economic Analysis, Fourth Edition, Pearson Education limited.

2. Allen.R.G.D, Mathematical Analysis for Economics, Mc Millan Press, London

3. Chiang.A.C, Fundamental Methods of Mathematical Economics, Mc Graw Hill, New Delhi.

MM 1331.5 – (1/1)

University of Kerala
Complimentary course in Mathematics for first degree programme in Economics
Semester III
Mathematics for Economics -III

Code : MM 1331.5

Instructional hours per week: 3

No.of Credits:3

Module 1: Simple Integration

Basic definition, constant of integration, basic rule of integration, standared results, Methods of integration(substitution methods only with simple problems), integration by parts(exept trigonometric functions and logarithmic functions), definite integral, properties of definite integrals(Without problems), Applications of definite integrals .

Chapter 12: 12.1, 12.2, 12.3, 12.4, 12.5 and 12.9 of Text 1

Chapter 13: 13.4 of Text 1

Module 2: Matrices and Determinants

Matrices: Addition and sutraction of matrices, matrix multiplication, transpose of a matrix, properties of transpose of a matrix(without problems), some special form of square matrices, Determinants, inverse if a matrix(Co factor method only). Solutions simultaneous equation by determinants- Cramer's rule.

Chapter 5: 5.1, 5.2, 5.3 , 5.5 , 5.6, 5.7, 5.10, 5.13 and 5.15 of Text 1

Text.1 Mehta Madnani, Mathematics for Economics,Sultan Chand and Sons Educational Publishers, New Delhi

References

1. Knut Sydsaeter and Peter Hammond with Arne Strom, Essential Mathematics for Economic Analysis, Fourth Edition, Pearson Education limited.

2. Allen.R.G.D, Mathematical Analysis for Economics, Mc Millan Press, London

3. Chiang.A.C, Fundamental Methods of Mathematical Economics, Mc Graw Hill, New Delhi.

MM 1431.2 —(2/2)

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

'he topics in this module can be found in chapter I [sections 1,2,4,5,6], chapter II [section 8] nd 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.

2018
Math Co

University of Kerala
Thiruvananthapuram, Kerala, India 695 034
(Established as University of Travancore by the Travancore University Act in 1937and reconstituted as University of Kerala by the Kerala University Act of 1957 and presently governed by the Kerala University Act of 1974 passed by the Kerala State Legislative Assembly)
(Re-accredited by NAAC with 'A' Grade)

No.Ac AV/1/2018

Thiruvananthapuram
Dated:26-06-2018

From

The Registrar

To

The Principals of all Colleges offering First Degree Programmes under CBCS system

Sub:- First Degree Programmes under CBCS system -Approved syllabus w.e.f 2018 admissions for intimation- reg.

Sir,

I am to inform you that the syllabus of the following First Degree Programmes under CBCS system have been revised from the Academic year 2018-19.

1. Computer Science
2. Computer Application
3. Physics & Computer Application (portions of Computer Application alone has been revised)
4. Physics
5. Mathematics
6. Geography
7. Statistics
8. Polymer Chemistry
9. Home Science
10. Commerce
11. Commerce with Computer Application
12. Commerce & Hotel Management and Catering
13. Commerce & Tax Procedure and Practice
14. Commerce & Tourism and Travel Management
15. Sanskrit (General)

16. Tamil
17. Malayalam
18. Malayalam and Mass Communication
19. Russian

20. Islamic History

The revised syllabus and the relevant U O's are uploaded in the University website for your information and further action.

Kindly take note of the same.

Yours faithfully,

Sd/-
Deputy Registrar(Acad-II)
For Registrar

Principal
V.T.M.N.S.S. College
Dhanuvachapuram

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

Principal
V.T.M.N.S.S. College
Dhanuvachapuram

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 – II	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 1545	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

FIRST DEGREE PROGRAMME UNDER CBCSS

SCHEME AND SYLLABI OF COMPLEMENTARY STATISTICS

FOR B. Sc. MATHEMATICS CORE w.e.f. 2018 Admission.

The goal of the syllabus is to equip the students with the concepts, principles and methods of Statistics. It is aimed that students be acquainted with the applications of statistical methods to analyze data and draw inferences wherever the statistical decisions are meaningful. Emphasis is given to understand the basic concepts and data analysis tools. There are practical sessions in each semester. Numerical problems solving using scientific calculators is also included in the End Semester Examination (ESE) of Courses in the semesters I, II, III & IV. There is one course in practical using Excel in Semester IV. ESE of courses in semesters I, II, III, & IV will be of 3 hours duration and have questions from all modules in the respective semester.

Courses in semesters I & II will be of 2 credits each and in semesters III & IV, 3 credits each. The ESE of Practical course in semester IV will be of 2 hours duration with credit 4.

It is mandatory to submit a fair record of practical done (module V of courses in semesters I, II, III and IV) and print-out of the output of the same duly certified at the time of ESE of practical course. ESE of the practical course will be held under the supervision of external examiners duly appointed by the University.

<table>
<tr><th rowspan="2">Semester</th><th rowspan="2">Title of the course</th><th colspan="2">Hours/ week</th><th rowspan="2">No. of credits</th><th rowspan="2">Total Hrs/ week</th><th rowspan="2">ESE Duration</th><th colspan="2">Weightage</th></tr>
<tr><th>L</th><th>P</th><th>CE</th><th>ESE</th></tr>
<tr><td>I</td><td>ST 1131.1: Descriptive Statistics</td><td>2</td><td>2</td><td>2</td><td>72</td><td>3 hrs</td><td>20</td><td>80</td></tr>
<tr><td>II</td><td>ST 1231.1: Probability and Random Variables</td><td>2</td><td>2</td><td>2</td><td>72</td><td>3 hrs</td><td>20</td><td>80</td></tr>
<tr><td>III</td><td>ST 1331.1: Statistical Distributions</td><td>3</td><td>2</td><td>3</td><td>90</td><td>3 hrs</td><td>20</td><td>80</td></tr>
<tr><td rowspan="2">IV</td><td>ST 1431.1: Statistical Inference</td><td rowspan="2">3</td><td rowspan="2">2</td><td>3</td><td rowspan="2">90</td><td>3 hrs</td><td>20</td><td>80</td></tr>
<tr><td>ST 1432.1: Practical using EXCEL</td><td>4</td><td>2 hrs</td><td>20</td><td>80</td></tr>
</table>

SEMESTER I

Hours/week: 4

ST 1131.1: Descriptive Statistics

The course aims that students will learn to understand the characteristics of data and will get acquainted with describing data through illustrating examples and exercises. They will also learn to collect, organize and summarize data, create and interpret simple graphs and compute appropriate summary statistics.

Module I: Part A: Introduction (Not for Examination Purpose): Significance of Statistics, Limitations and misuse of Statistics, Official Statistical system of India. Types of Data: Concepts of primary data and secondary data, population and sample; Classification of data based on geographic, chronological, qualitative and quantitative characteristics.

Part B: Collection and Presentation of Data: Scales of data-Nominal, Ordinal, Ratio and Interval. Methods of collection of primary data–Preparation of questionnaires / schedules. Secondary data –major sources and limitations; Census and Sample Surveys; Methods of sampling: Probability and non-probability sampling, simple random sampling with replacement (SRSWR) & simple random sampling without replacement (SRSWOR), Systematic sampling and Stratified sampling (concepts only); sampling and non-sampling errors; Presentation of raw data: Classification and tabulation - Construction of Tables with one or more factors of classification, frequency distributions, relative and cumulative frequency distributions, their graphical representations.

Module II: Summarization of Data: Central tendency- mean, median, mode, geometric mean, harmonic mean; properties of Arithmetic Mean and Median; Relationship between AM, GM and HM; Absolute and relative measures of dispersion: Range, quartile deviation, mean deviation and standard deviation; Properties of mean deviation, standard deviation, combined mean and combined standard deviation; coefficient of variation; Moments- Raw and central moments; relationship between raw and central moments; effect of change of origin and scale; Skewness, Kurtosis and their measures.

Module III: **Bivariate data**: Scatter diagram, Fitting of curves- Principle of least squares, fitting of straight line, fitting parabola, curves $y=ab^x$, $y=ax^b$, $y=ae^{bx}$, and $y=ax^{-1}+b$.

Module IV: Regression lines and prediction, Karl Pearson's coefficient of correlation, Spearman's rank correlation.

Module V: Practical based on Modules I, II, III, & IV – Data analysis: presentation of data –Charts and Diagrams, Frequency table, Frequency graphs, calculation of descriptive statistics, curve fitting, correlation and regression.

References

1. Gupta S.C. and Kapoor V.K. (1980). *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons, New Delhi.
2. Gupta, S. C., and Kapoor, V. K. (1994). *Fundamental of Mathematical Statistics*. Sultan Chand & Sons, New Delhi.
3. Gupta S. P. (2004). *Statistical Methods*. Sultan Chand & Sons, New Delhi.
4. Kenny J. F & Keeping E. S (1964). *Mathematics of Statistics –Part Two*. 2nd Edition, D. Van Nostard Company, New Delhi-1.
5. Kenny J. F (1947). *Mathematics of Statistics Part One*. 2nd Edition, D. Van Nostard Company, New Delhi-1. **ASIN: B0013G0LYA.**
6. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
7. Agarwal, B.L. (2006). *Basic Statistics*. 4th Edition New Age international(P) Ltd., New Delhi. **ISBN: 8122418147, 9788122418149.**
8. Agarwal, B.L.(2013). *Basic Statistics*. Anshan, Uk. **ISBN-13: 978-1848290679; ISBN-10: 1848290675.**

SEMESTER II

Hours/week: 4

ST 1231.1: Probability and Random variables

This course will introduce the elementary ideas of probability and random variables.

Module I: Random experiments- sample point and sample space- Events, algebra of events, concepts of equally likely, mutually exclusive and exhaustive events; Probability: Statistical regularity, relative frequency and classical approaches, Axiomatic approach, theorems in probability, probability space.

Module II: Conditional probability, multiplication theorem, independence of two and three events, compound probability, Bayes' theorem and its applications.

Module III: Random variables- discrete and continuous, probability mass function and probability density function, distribution function, joint distribution of two random variables, marginal and conditional distributions, independence, transformation of variables- one-to-one transformation-univariate.

Module IV: Expectation of random variables and its properties, theorems on expectation of sums and product of independent random variables, conditional expectation, moments, moment generating function, characteristic function, their properties and uses; Bivariate moments, Cauchy- Schwartz inequality and correlation coefficient.

Module V: Practical (Numerical Problems) based on Modules I, II, III, & IV - random variables (univariate and bivariate), expectations and moments.

References

1. Bhat B.R. (1985). *Modern Probability Theory*. New Age International (P) Ltd, New Delhi.
2. Dudewicz E.J and Mishra S.N (1988). *Modern Mathematical Statistics*. John Wiley & Sons, New York.
3. Gupta, S. C., and Kapoor, V. K. (1994). *Fundamental of Mathematical Statistics*. Sultan Chand & Sons. New Delhi.
4. Pitman, J. (1993). *Probability*. Narosa Publishing House, New Delhi
5. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
6. Rohatgi V. K.(1993). *An Introduction to Probability Theory and Mathematical Statistics*. Wiley Eastern, New Delhi.
7. Rao C.R (1973). *Linear Statistical Inference and its Applications*. 2/e, Wiley, New York.

SEMESTER III

Hours/week: 5

ST 1331.1: Statistical Distributions

This course introduces standard probability distributions, limit theorems and sampling distributions.

Module I: Standard Distributions(Discrete)- Uniform, binomial, Poisson and geometric- moments, moment generating function, characteristic function, problems, additive property (binomial and Poisson), recurrence relation (binomial and Poisson), Poisson as a limiting form of binomial, memory less property of geometric distribution; Fitting of binomial and Poisson distributions; hypergeometric distribution(definition, mean and variance only).

Module II: Standard Distributions (Continuous)– Uniform, exponential, and gamma - moment generating function, characteristic function, problems; memory less property of exponential distribution; additive property of gamma distribution; beta distribution (I and II)- moments, Normal distribution- moments, moment generating function, characteristic function, problems, recurrence relation of central moments; convergence of binomial and Poisson to normal.

Module III: Chebychev's inequality; Law of large numbers-BLLN, convergence in probability (definition only), WLLN; central limit theorem for iid random variables- statement and applications.

Module IV: Sampling distributions -Parameter and statistic, Sampling distributions- Distribution of mean of a sample taken from a normal population, Chi-square(χ^2)- definition and properties, t and F distributions (definitions only) and statistics following these distributions, relation between normal, χ^2, t and F distributions.

Module V: Practical based on Modules I, II, III, & IV – Discrete and continuous probability distributions and applications, law of large numbers and CLT.

References

1. Medhi J.(2005). *Statistical Methods-An Introductory Text*. New Age International (P) Ltd, New Delhi.
2. Gupta S.C. and Kapoor V.K. (1980). *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons, New Delhi.
3. John E. Freund(1980). *Mathematical Statistics*. Prentice Hall of India, New Delhi.
4. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
5. Rohatgi V. K.(1993). *An Introduction to Probability Theory & Mathematical Statistics*. Wiley-Eastern, New Delhi.

SEMESTER IV

Hours/week: 5

ST 1431.1: Statistical Inference

This course enables the students to understand the methods of Statistical Inference.

Module I: Point estimation, Properties of estimators – unbiasedness, consistency, efficiency and sufficiency; Methods of estimation - Maximum likelihood method, method of moments; Interval estimation of mean, variance and proportion (single unknown parameter only).

Module II: Testing of Hypothesis- statistical hypotheses, simple and composite hypotheses, two types of errors, significance level, p-value, power of a test, Neyman-Pearson lemma (without proof) .

Module III: Large sample tests- testing mean and proportion (one and two sample cases), Chi-square (χ^2) test of goodness of fit, independence and homogeneity.

Small sample tests- Z-test for means; One sample test for mean of a normal population, Equality of means of two independent normal populations, Paired samples t-test, Chi-square test for variance, F-test for equality of variances.

Module IV: Design of Experiments- assumptions, principles, models and ANOVA tables of one way and two way classified data (Derivation of two – way model is not included).

Module V: Practical based on Modules I, II , III & IV.

References

1. Das M. N., Giri N. C.(2003). *Design and analysis of experiments*. New Age International (P) Ltd, New Delhi.
2. John E. Freund(1980). *Mathematical Statistics*. Prentice Hall of India, New Delhi.
3. Medhi J. (2005). *Statistical Methods-An Introductory Text*, New Age International(P) Ltd.. New Delhi.
4. Paul G. Hoel, Sidney C. Port, Charles J. Stone (1971). *Introduction to Statistical Theory*. Universal Book stall, New Delhi.

Course V - ST 1432.1: Practical using Excel

The students will learn to use statistical tools available in Excel and have hands on training in data analysis.

This course covers topics of courses I, II, III & IV.

Use of Excel in statistics (Charts, functions and data analysis),

Practical covering Semesters I, II, III, & IV

Section I: Charts- Bar chart, Pie chart & scatter diagram

Functions- Evaluation of numerical problems using the following functions

AVEDEV	AVERAGE	BINORMDIST	CHIDIST	CHINV	CHITEST
CONFIDENCE	CORREL	COVAR	DEVSQ	FDIST	FINV
FREQUENCY	FTEST	GEOMEAN	HARMEAN	INTERCEPT	KURT
MEDIAN	MODE	LINEST	LOGEST	NORMDIST	NORMINV
NORMSDIST	PEARSON	POISSON	PROB	SKEW	SLOPE
STANDARDIZE	STDEVP	TDIST	TINV	TREND	TTEST

Section II: Data analysis

Histogram, Descriptive Statistics, Covariance, Correlation, Regression, Random Number Generation, Sampling, t-tests for means: Paired t-test, Equality of means of two normal populations, z-test: Two Sample test for Means, F-test for Variances, ANOVA- Single Factor and Two Factor without Replication.

References

1. Dan Remenyi, George Onofrei, Joe English (2010). *An Introduction to Statistics Using Microsoft Excel*. Academic Publishing Ltd., UK

2. Neil J Salkind (2010). *Excel Statistics, A Quick Guide*. SAGE Publication Inc. New Delhi

3.Vijai Gupta (2002). *Statistical Analysis with Excel*. VJ Books Inc. Canada

Record of Practical

Duly certified record of practical sessions is mandatory to appear for the practical examination. Five questions are to be worked out in each sheet based on the topics given below:

Sheets

1. Diagrams and Graphs
2. Measures of Central Tendency and Dispersion
3. Moments, Skewness and Kurtosis
4. Fitting of Curves
5. Correlation and Regression
6. Probability
7. Univariate Random Variables
8. Bivariate Random Variables
9. Mathematical Expectation
10. Bivariate Moments
11. Standard Distributions- Discrete
12. Standard Distributions- Continuous
13. Law of Large Numbers
14. Sampling Distributions
15. Point Estimation
16. Interval Estimation
17. Large Sample Tests
18. Small Sample Tests
19. Analysis of Variance
20. Charts in Excel
21. Functions in Excel
22. Analysis Tools in Excel

Print-out of output of practical sheets 20, 21 and 22 are to be attached. CE and ESE marks are to be awarded and consolidated as per regulations of the FDP in affiliated Colleges, 2013.

FIRST DEGREE PROGRAMME UNDER CBCSS

SCHEME AND SYLLABI OF COMPLEMENTARY STATISTICS FOR B. Sc. MATHEMATICS CORE w.e.f. 2018 Admission.

The goal of the syllabus is to equip the students with the concepts, principles and methods of Statistics. It is aimed that students be acquainted with the applications of statistical methods to analyze data and draw inferences wherever the statistical decisions are meaningful. Emphasis is given to understand the basic concepts and data analysis tools. There are practical sessions in each semester. Numerical problems solving using scientific calculators is also included in the End Semester Examination (ESE) of Courses in the semesters I, II, III & IV. There is one course in practical using Excel in Semester IV. ESE of courses in semesters I, II, III, & IV will be of 3 hours duration and have questions from all modules in the respective semester.

Courses in semesters I & II will be of 2 credits each and in semesters III & IV, 3 credits each. The ESE of Practical course in semester IV will be of 2 hours duration with credit 4.

It is mandatory to submit a fair record of practical done (module V of courses in semesters I, II, III and IV) and print-out of the output of the same duly certified at the time of ESE of practical course. ESE of the practical course will be held under the supervision of external examiners duly appointed by the University.

Semester	Title of the course	Hours/ week		No. of credits	Total Hrs/ week	ESE Duration	Weightage	
		L	P				CE	ESE
I	ST 1131.1: Descriptive Statistics	2	2	2	72	3 hrs	20	80
II	ST 1231.1: Probability and Random Variables	2	2	2	72	3 hrs	20	80
III	ST 1331.1: Statistical Distributions	3	2	3	90	3 hrs	20	80
IV	ST 1431.1: Statistical Inference	3	2	3	90	3 hrs	20	80
	ST 1432.1: Practical using EXCEL			4		2 hrs	20	80

SEMESTER I

Hours/week: 4

ST 1131.1: Descriptive Statistics

The course aims that students will learn to understand the characteristics of data and will get acquainted with describing data through illustrating examples and exercises. They will also learn to collect, organize and summarize data, create and interpret simple graphs and compute appropriate summary statistics.

Module I: Part A: Introduction (Not for Examination Purpose): Significance of Statistics, Limitations and misuse of Statistics, Official Statistical system of India. Types of Data: Concepts of primary data and secondary data, population and sample; Classification of data based on geographic, chronological, qualitative and quantitative characteristics.

Part B: Collection and Presentation of Data: Scales of data-Nominal, Ordinal, Ratio and Interval. Methods of collection of primary data–Preparation of questionnaires / schedules. Secondary data –major sources and limitations; Census and Sample Surveys; Methods of sampling: Probability and non-probability sampling, simple random sampling with replacement (SRSWR) & simple random sampling without replacement (SRSWOR), Systematic sampling and Stratified sampling (concepts only); sampling and non-sampling errors; Presentation of raw data: Classification and tabulation - Construction of Tables with one or more factors of classification, frequency distributions, relative and cumulative frequency distributions, their graphical representations.

Module II: Summarization of Data: Central tendency- mean, median, mode, geometric mean, harmonic mean; properties of Arithmetic Mean and Median; Relationship between AM, GM and HM; Absolute and relative measures of dispersion: Range, quartile deviation, mean deviation and standard deviation; Properties of mean deviation, standard deviation, combined mean and combined standard deviation; coefficient of variation; Moments- Raw and central moments; relationship between raw and central moments; effect of change of origin and scale; Skewness, Kurtosis and their measures.

Module III: **Bivariate data**: Scatter diagram, Fitting of curves- Principle of least squares, fitting of straight line, fitting parabola, curves $y=ab^x$, $y=ax^b$, $y=ae^{bx}$, and $y=ax^{-1}+b$.

Module IV: Regression lines and prediction, Karl Pearson's coefficient of correlation, Spearman's rank correlation.

Module V: Practical based on Modules I, II, III, & IV – Data analysis: presentation of data –Charts and Diagrams, Frequency table, Frequency graphs, calculation of descriptive statistics, curve fitting, correlation and regression.

References

1. Gupta S.C. and Kapoor V.K. (1980). *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons, New Delhi.
2. Gupta, S. C., and Kapoor, V. K. (1994). *Fundamental of Mathematical Statistics*. Sultan Chand & Sons, New Delhi.
3. Gupta S. P. (2004). *Statistical Methods*. Sultan Chand & Sons, New Delhi.
4. Kenny J. F & Keeping E. S (1964). *Mathematics of Statistics –Part Two*. 2nd Edition, D. Van Nostard Company, New Delhi-1.
5. Kenny J. F (1947). *Mathematics of Statistics Part One*. 2nd Edition, D. Van Nostard Company, New Delhi-1. **ASIN: B0013G0LYA.**
6. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
7. Agarwal, B.L. (2006). *Basic Statistics*. 4th Edition New Age international(P) Ltd., New Delhi. **ISBN: 8122418147, 9788122418149.**
8. Agarwal, B.L.(2013). *Basic Statistics*. Anshan, Uk. **ISBN-13: 978-1848290679; ISBN-10: 1848290675.**

SEMESTER II

Hours/week: 4

ST 1231.1: Probability and Random variables

This course will introduce the elementary ideas of probability and random variables.

Module I: Random experiments- sample point and sample space- Events, algebra of events, concepts of equally likely, mutually exclusive and exhaustive events; Probability: Statistical regularity, relative frequency and classical approaches, Axiomatic approach, theorems in probability, probability space.

Module II: Conditional probability, multiplication theorem, independence of two and three events, compound probability, Bayes' theorem and its applications.

Module III: Random variables- discrete and continuous, probability mass function and probability density function, distribution function, joint distribution of two random variables, marginal and conditional distributions, independence, transformation of variables- one-to-one transformation- univariate.

Module IV: Expectation of random variables and its properties, theorems on expectation of sums and product of independent random variables, conditional expectation, moments, moment generating function, characteristic function, their properties and uses; Bivariate moments, Cauchy- Schwartz inequality and correlation coefficient.

Module V: Practical (Numerical Problems) based on Modules I, II, III, & IV - random variables (univariate and bivariate), expectations and moments.

References

1. Bhat B.R. (1985). *Modern Probability Theory*. New Age International (P) Ltd, New Delhi.
2. Dudewicz E.J and Mishra S.N (1988). *Modern Mathematical Statistics*. John Wiley & Sons, New York.
3. Gupta, S. C., and Kapoor, V. K. (1994). *Fundamental of Mathematical Statistics*. Sultan Chand & Sons. New Delhi.
4. Pitman, J. (1993). *Probability*. Narosa Publishing House, New Delhi
5. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
6. Rohatgi V. K.(1993). *An Introduction to Probability Theory and Mathematical Statistics*. Wiley Eastern, New Delhi.
7. Rao C.R (1973). *Linear Statistical Inference and its Applications*. 2/e, Wiley, New York.

SEMESTER III

Hours/week: 5

ST 1331.1: Statistical Distributions

This course introduces standard probability distributions, limit theorems and sampling distributions.

Module I: Standard Distributions(Discrete)- Uniform, binomial, Poisson and geometric- moments, moment generating function, characteristic function, problems, additive property (binomial and Poisson), recurrence relation (binomial and Poisson), Poisson as a limiting form of binomial, memory less property of geometric distribution; Fitting of binomial and Poisson distributions; hypergeometric distribution(definition, mean and variance only).

Module II: Standard Distributions (Continuous)– Uniform, exponential, and gamma - moment generating function, characteristic function, problems; memory less property of exponential distribution; additive property of gamma distribution; beta distribution (I and II)- moments, Normal distribution- moments, moment generating function, characteristic function, problems, recurrence relation of central moments; convergence of binomial and Poisson to normal.

Module III: Chebychev's inequality; Law of large numbers-BLLN, convergence in probability (definition only), WLLN; central limit theorem for iid random variables- statement and applications.

Module IV: Sampling distributions -Parameter and statistic, Sampling distributions- Distribution of mean of a sample taken from a normal population, Chi-square(χ^2)- definition and properties, t and F distributions (definitions only) and statistics following these distributions, relation between normal, χ^2 , t and F distributions.

Module V: Practical based on Modules I, II, III, & IV – Discrete and continuous probability distributions and applications, law of large numbers and CLT.

References

1. Medhi J.(2005). *Statistical Methods-An Introductory Text*. New Age International (P) Ltd, New Delhi.
2. Gupta S.C. and Kapoor V.K. (1980). *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons, New Delhi.
3. John E. Freund(1980). *Mathematical Statistics*. Prentice Hall of India, New Delhi.
4. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
5. Rohatgi V. K.(1993). *An Introduction to Probability Theory & Mathematical Statistics*. Wiley-Eastern, New Delhi.

SEMESTER IV

Hours/week: 5

ST 1431.1: Statistical Inference

This course enables the students to understand the methods of Statistical Inference.

Module I: Point estimation, Properties of estimators – unbiasedness, consistency, efficiency and sufficiency; Methods of estimation - Maximum likelihood method, method of moments; Interval estimation of mean, variance and proportion (single unknown parameter only).

Module II: Testing of Hypothesis- statistical hypotheses, simple and composite hypotheses, two types of errors, significance level, p-value, power of a test, Neyman-Pearson lemma (without proof) .

Module III: Large sample tests- testing mean and proportion (one and two sample cases), Chi-square (χ^2) test of goodness of fit, independence and homogeneity.

Small sample tests- Z-test for means; One sample test for mean of a normal population, Equality of means of two independent normal populations, Paired samples t-test, Chi-square test for variance, F-test for equality of variances.

Module IV: Design of Experiments- assumptions, principles, models and ANOVA tables of one way and two way classified data (Derivation of two – way model is not included).

Module V: Practical based on Modules I, II , III & IV.

References

1. Das M. N., Giri N. C.(2003). *Design and analysis of experiments*. New Age International (P) Ltd, New Delhi.
2. John E. Freund(1980). *Mathematical Statistics*. Prentice Hall of India, New Delhi.
3. Medhi J. (2005). *Statistical Methods-An Introductory Text*, New Age International(P) Ltd.. New Delhi.
4. Paul G. Hoel, Sidney C. Port, Charles J. Stone (1971). *Introduction to Statistical Theory*. Universal Book stall, New Delhi.

Course V - ST 1432.1: Practical using Excel

The students will learn to use statistical tools available in Excel and have hands on training in data analysis.

This course covers topics of courses I, II, III & IV.

Use of Excel in statistics (Charts, functions and data analysis),

Practical covering Semesters I, II, III, & IV

Section I: Charts- Bar chart, Pie chart & scatter diagram

Functions- Evaluation of numerical problems using the following functions

AVEDEV	AVERAGE	BINORMDIST	CHIDIST	CHINV	CHITEST
CONFIDENCE	CORREL	COVAR	DEVSQ	FDIST	FINV
FREQUENCY	FTEST	GEOMEAN	HARMEAN	INTERCEPT	KURT
MEDIAN	MODE	LINEST	LOGEST	NORMDIST	NORMINV
NORMSDIST	PEARSON	POISSON	PROB	SKEW	SLOPE
STANDARDIZE	STDEVP	TDIST	TINV	TREND	TTEST

Section II: Data analysis

Histogram, Descriptive Statistics, Covariance, Correlation, Regression, Random Number Generation, Sampling, t-tests for means: Paired t-test, Equality of means of two normal populations, z-test: Two Sample test for Means, F-test for Variances, ANOVA- Single Factor and Two Factor without Replication.

References

1. Dan Remenyi, George Onofrei, Joe English (2010). *An Introduction to Statistics Using Microsoft Excel*. Academic Publishing Ltd., UK

2. Neil J Salkind (2010). *Excel Statistics, A Quick Guide*. SAGE Publication Inc. New Delhi

3.Vijai Gupta (2002). *Statistical Analysis with Excel*. VJ Books Inc. Canada

Record of Practical

Duly certified record of practical sessions is mandatory to appear for the practical examination. Five questions are to be worked out in each sheet based on the topics given below:

Sheets

1. Diagrams and Graphs
2. Measures of Central Tendency and Dispersion
3. Moments, Skewness and Kurtosis
4. Fitting of Curves
5. Correlation and Regression
6. Probability
7. Univariate Random Variables
8. Bivariate Random Variables
9. Mathematical Expectation
10. Bivariate Moments
11. Standard Distributions- Discrete
12. Standard Distributions- Continuous
13. Law of Large Numbers
14. Sampling Distributions
15. Point Estimation
16. Interval Estimation
17. Large Sample Tests
18. Small Sample Tests
19. Analysis of Variance
20. Charts in Excel
21. Functions in Excel
22. Analysis Tools in Excel

Print-out of output of practical sheets 20, 21 and 22 are to be attached. CE and ESE marks are to be awarded and consolidated as per regulations of the FDP in affiliated Colleges, 2013.

Board of Studies in Mathematics (UG)
UNIVERSITY OF KERALA

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

REVISED SYLLABUS
2014 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	Algebra and Calculus-I	5	4
IV	MM 1441	Algebra and Calculus-II	5	4
V	MM 1541	Real Analysis-I	5	4
	MM 1542	Complex Analysis I	4	3
	MM 1543	Differential Equations	3	3
	MM 1544	Vector Analysis	3	3
	MM 1545	Abstract Algebra I	5	4
	MM 1551	Open Course	3	2
		Project	2	
VI	MM 1641	Real Analysis-II	5	4
	MM 1642	Linear Algebra	4	3
	MM 1643	Complex Analysis II	3	3
	MM 1644	Abstract Algebra II	3	3
	MM 1645	Computer Programming (Pract.)	5	4
	MM 1651	Elective Course	3	2
	MM 1646	Project	2	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	Actuarial Science	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	Fuzzy Mathematics	3	2
VI	MM 1661.3	Mechanics	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	Differentiation and Analytic Geometry	4	3
MM 1231.1	2	Integration and Vectors	4	3
MM 1331.1	3	Theory of Eqs., Differential Eqs., and Theory of Matrices	5	4
MM 1431.1	4	Complex Analysis, Fourier Series and Transforms	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	Differentiation and Matrices	4	3
MM 1231.2	2	Integration, Differential Eqs. and Analytic Geometry	4	3
MM 1331.2	3	Theory of Eqs.and Vector Analysis	5	4
MM 1431.2	4	Abstract Algebra and Linear Transformations	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	Differentiation and Theory of Equations	4	3
MM 1231.3	2	Integration, Differential Eqs. and Matrices	4	3
MM 1331.3	3	Analytic Geometry, Complex Nos. and Abstract Algebra	5	4
MM 1431.3	4	Vector Analysis and Fourier Series	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	Theory of Eqs., Infinite Series and Analytic Geometry	4	3
MM 1231.4	2	Differential Calculus	4	3
MM 1331.4	3	Integration and Complex Nos.	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

Module I Algebra

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

In this part of the course, we study the basic properties of natural numbers, traditionally called *Theory of Numbers*. It is based on Chapters 2–5 of the text. Students should be encouraged to read the textbook and try to do the problems on their own, to gain practice in writing algebraic proofs. All the problems and exercises at the end of each section are to be discussed.

We start with the methods of proofs by induction, as in Sections A and B of Chapter 2. The intuitive idea that these methods give a scheme of extending a result from one natural number to the next *independent of the number under consideration* should be stressed. The fact that the second principle is easier in some cases should be illustrated through examples such as Example 1 of Section B. *The logical equivalence of these two methods (Theorems 1 and 2 of Section B) need not be discussed.*

We then pass onto THE WELL ORDERING PRINCIPLE, as in Section C. Example E1, Theorem 1 and Proposition 3 should be discussed with proofs based on this principle. *The deduction of this principle from the principle of induction, as in Theorem 2, need not be done.* Thus the two principles of induction and the well-ordering principle need only be discussed as intuitively obvious properties of natural numbers.

Before introducing the DIVISION THEOREM, as in Section D, the usual process of long division to get the *quotient* and *remainder* must be recalled through examples and the formal proof of this theorem should be linked to these examples. After proving the this theorem and the UNIQUENESS PROPOSITION as in this section, the representation of natural numbers in different bases can be explained as in Section E. *The last section of Chapter 2 on operations in different bases (Section F) need not be discussed.*

The idea of the GREATEST COMMON DIVISOR of two natural numbers, studied in elementary class, is to be recalled next and the *existence* of a such a number justified, as in Section A of Chapter 3. The idea of *coprimality* is also to be considered here. Some of the important properties of coprime numbers, as in Exercises E9, E10 and E11 must be discussed. Next, EUCLID'S ALGORITHM and some of its applications are to be discussed, as in Section B. After discussing the theoretical consequences of Euclid's Algorithm, namely *Bezout's Identity* and its corollaries, as in Section C, its practical use in solving indeterminate equations of the first degree is to be discussed, as in the text. (See also `http://en.wikipedia.org/wiki/Diophantine_equation`) *The last two sections of this chapter on the efficiency of Euclid's Algorithm (Section D) and on incommensurability (Section E) need not be discussed.*

A discussion on primes and THE FUNDAMENTAL THEOREM ON ARITHMETIC, as given in the first three section of Chapter 4 are to be done next. *The last section of this chapter on primes in an interval need not be discussed.*

Finally we introduce the new idea of congruences as in Chapter 5. The fact that when an integer is divided by another, the dividend is congruent to the remainder modulo the divisor should be emphasized. In discussing the basic properties of congruences the fact that the cancellation of common factors does not hold in general for congruences should be emphasized and illustrated through examples. This part of the course is based on Sections A, B, C of Chapter 5.

Module 2 Calculus

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, the basic ideas of differentiation of real valued functions are considered. It is based on Chapters 1–3 of the text.

We start with the intuitive idea of a function as the dependence of one quantity on another as in the subsection titled FUNCTIONS of Section 1.1 of the text and pass on to Definitions 1.1.1 and 1.1.2. We next discuss basic properties of functions, as in Section 1.2. It must be emphasized through illustrations that not all equations connecting two variables give one variable as a function of the other, as in Example 1 of Section 1.2 of the text. (The notion of *explicit* and *implicit* definitions of functions and their graphs, as given in the first two parts of Section 3.6 can be discussed here itself.) Functions defined piecewise and their graphs must be specially mentioned and illustrated. Approximate solutions to problems through graphical methods are to be explained as in Example 7 of the section. Section 1.3 on using computers may be skipped, but the use of computers in plotting graphs should be demonstrated, using Open Source Software such as GeoGebra or Gnuplot.

(See also `http://www-groups.dcs.st-and.ac.uk/~history/Curves/Curves.html`)

Some of the ideas in Section 1.4, such as arithmetic operations on functions, maybe familiar to the students, but they should be reviewed. Other ideas such as symmetry, stretching and compression and translation maybe new and should be emphasized. Section 1.5 named LINES maybe supplemented with Appendix C, COORDINATE PLANES AND LINES. *Section 1.6 on families of functions and Section 1.7 on mathematical modelling need not be discussed.* But parametric equations, especially that of the cycloid, must be discussed in detail, as in Section 1.8.

Limits and continuity are concepts introduced in Higher Secondary class. In this course, the intuitive description of of these ideas are to be reinforced through tabulation and plotting and illustrated through examples, as in Sections 2.1–2.3. *The rigorous description of limits, as in Section 2.4, need not be discussed.* Sections 2.5 and 2.6 on continuity must be discussed.

The notion of differentiation is also familiar to the students. Here, this idea is to be re-introduced through applications as in the first two sections of Chapter 3.

(See also `http://en.wikipedia.org/wiki/History_of_calculus`) The discussion of VELOCITY AND SLOPES at the beginning of Section 3.1 maybe based on Example 1 of Section 2.1, instead of the unfamiliar bell-pulling example. Much of the material in Sections 3.3–3.7 maybe already seen, but they should be reviewed, emphasizing the graphical meaning and applications. The idea of implicit differentiation should be made clear, as in Section 3.6. *The last section on approximations, Section 3.8, need not be discussed.*

Module 3 Analytic Geometry

Text: Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

This part of the course is a detailed discussion on conics, based on Sections 11.4, 11.5 and parts of 11.6 of the text. Students are introduced to the standard equation of the conics in the Higher Secondary class, but little else on conics. Here we start with the geometrically unified description of conics as sections of a cone, as in the subsection conic sections of Section 11.4 of the text (see also `http://en.wikipedia.org/wiki/Conic_sections`) and pass on to the description subsection DEFINITION OF THE CONIC SECTIONS. Various problems in EXERCISE SET 11.4 on practical applications of conics should be discussed. Theorem 11.6.1 and the discussions following it are to be discussed next. (The connection between the description of conics as sections of cone and using the focus-directrix property can be in `http://en.wikipedia.org/wiki/Dandelin_spheres`) Finally, the geometric and algebraic description of conics tilted with respect to the coordinate axes are discussed as in Section 11.5, culminating in Theorem 11.5.2 characterizing the graphs of all second degree equations in two variables.

The final aim of this part is to give a complete characterization of graphs of second degree equations in two variables as given in Theorem 11.5.2, thus giving an algebraically unified description of conics.

REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.

2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.

3. S.Lang, *A first Calculus*, Springer.

Distribution of instructional hours:

Module 1: 24 hours; Module 2: 36 hours; Module 3: 12 hours

Semester II

Foundations of Mathematics

CODE: MM 1221 Instructional hours per week: 4

No.of credits: 3

Module I Algebra

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

We continue the study of the theory of numbers, based on parts of Chapters 5–7 and Chapters 9–10 of the text. (Chapter 8, discussing abstract ideas is postponed to the next semester.)

We start with Sections D and E of Chapter 5, which discuss more properties and applications of the idea of congruence introduced in the first semester course. We then pass on to the idea of congruence classes and related ideas, as in Chapter 6 of the text. The notion of Congruence modulo m, done in the first semester, is now introduced as an equivalence relation and the congruence classes modulo m are discussed through examples such as $\mathbb{Z}/2\mathbb{Z}$ and $\mathbb{Z}/12\mathbb{Z}Z$ (clock arithmetic), leading to the general set $\mathbb{Z}/m\mathbb{Z}$. Here we can recall the ideas of equivalence relation (learnt in Higher Secondary class) and partition and the relation between the two. The sections named RATIONAL NUMBERS, EQUIVALENCE CLASSES and NATURAL NUMBERS of Chapter 1 should be used to supplement this discussion. As applications, only Section A of Chapter 7 on ROUND ROBIN TOURNAMENTS and Section C on TRIAL DIVISION need be discussed.

Next we move on to Fermat's and Euler's Theorems, as in Chapter 9. Only the first four sections of this chapter need be done. (The other sections are to be discussed in the next semester.) In Section C, exercises E7–E10 on the computation of Euler's phi function must be done and used to compute the phi-value of some specific numbers see also Bernard and Child, *Higher Algebra*. As an applications, only FINDING HIGHER POWERS MODULO m (Section D of Chapter 9, see also `http://en.wikipedia.org/wiki/RSA`), RSA CODES Mersenne Numbers and Fermat Numbers (Section C of Chapter 10) need be done.

Module 2 Calculus

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part, we continue the discussion on calculus and analytic geometry started in the first semester. It is based on parts of Chapters 4–8 and Chapter 11 of the text.

We start with the discussion on how the derivative of a function can be used to visualize the graph of the function in better detail, as described in Sections 4.1–4.3 of the text. We then discuss how the ideas of maxima and minima can be used to solve practical problems, as in Section 4.5. *Sections 4.4, 4.7 and 4.8 need not be discussed.*

We next introduce the idea of integration as anti-differentiation, as in Definition 5.2.1. As motivation for this idea, the first two subsections, FINDING POSITION AND VELOCITY BY INTEGRATION and UNIFORMLY ACCELERATED MOTION of Section 5.7 can be used. *The lat two subsections of Section 5.2,* INTEGRATION FROM THE VIEWPOINT OF DIFFERENTIAL EQUATIONS *and* DIRECTION FIELDS, *need not be discussed.* After completing Sections 5.2 and 5.3, we turn to the area problem, as in Section 5.1. We pass on to the subsections DEFINITION OF AREA and NET SIGNED AREA of Section 5.4. Only Definitions 5.4.3 and 5.4.5 of this section and the discussions preceding these need be discussed. We then discuss the subsection RIEMANN SUMS AND THE DEFINITE INTEGRAL of Section 5.5. Only Definition 5.5.1 and Theorems 5.5.4 and 5.5.5 of this section need be discussed. The connection between anti-differentiation and Riemann integration is to be discussed next, as in the subsection THE FUNDAMENTAL THEOREM OF CALCULUS of Section 5.6. *The proof of Theorem 5.6.1 and the remaining parts of this section need not be discussed.* But Sections 5.7 and 5.8 are to be discussed in full. Applications of integration comes next, as in Sections 6.1–6.5 of the test. *Sections 6.6 and 6.7 need not be discussed.*

Though the idea of inverse functions is introduced in the Higher Secondary class, this has to be done in a more thorough manner as in Section 7.1. Also, the ideas have to be graphically interpreted. Before discussing the exponential and logarithmic functions, the idea of irrational exponents has to be made clear, as in Section 7.2. After Section 7.3 on differentiation and integration of the exponential and logarithmic functions, Section 7.6 on inverse trigonometric functions, Section 7.7 on LH́ospital's Rule and Section 7.8 on hyperbolic functions are to be done in full. *Sections 7.4 and 7.5 need not be discussed.*

Various techniques of integration are to be considered next, as in Sections 8.1–8.5. Then improper integrals are to be discussed as in Section 8.8. *The other sections, 8.6 and 8.7 need not be discussed.*

Module 3 Analytical Geometry

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, we introduce polar coordinates as in Section 11.1 of the text. Areas in polar coordinates are to be done as in Section 11.3 and the polar equations of conics as in Section 11.6. The subsection APPLICATIONS IN ASTRONOMY must also be discussed.

REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. S.Lang, *A first Calculus*, Springer.

Distribution of instructional hours:

Module 1: 24 hours; Module 2: 36 hours; Module 3: 12 hours

Semester III

Algebra and Calculus I

CODE: MM 1341 — Instructional hours per week: 5

No.of credits: 4

Module I Algebra

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

Continuing the discussion on number theory in the first two semesters, here we make first contact with the part of mathematics currently called *Abstract Algebra*. It is based on parts of Chapters 8, 9, and 12 of the text.

Contrary to the usual stand-alone courses on abstract algebra, we introduce rings before groups, since the former arise naturally as generalizations of number systems. Sections A and B of Chapter 8, (including the problems) are to be discussed in full. *In section C, the definition of characteristic and the rest of the portions need not be discussed*. More examples of rings and exercises on homomorphism can be given to get a clear idea of the concepts.

Next comes a discussion on the units of the ring of congruence classes leading to the definition of an abstract group and then the GROUP OF UNITS of an abstract ring, as in Section E and Section F of Chapter 9. This culminates in the ABSTRACT FERMAT'S THEOREM, as in Section E. *The proofs of generalized associativity or generalized commutativity need not be discussed*. But the fact that a set G with an associative multiplication is a group, if it either has the identity and inverse properties or has the cancellation and solvability properties has to be proved (see T. W .Hungerford, *Algebra*). The exponent of an Abelian group, as in Section 9F also has to be discussed. As an illustration of the interplay between number theory and abstract algebra, we consider the THE CHINESE REMAINDER THEOREM, as in Section A of Chapter 12. Only the first part and the problems E1, E2, E3 and E4 of this section need be discussed , *The alternate method of reducing all the congruences to one need not be considered*. As another application, the multiplicative property of the phi function discussed earlier must be redone (Corollary 3 of Section C). The square roots of 1 modulo some integer, as in Section C of Chapter 12 must also be discussed.

REFERENCES:

1. J B Fraleigh, *A First Course in Abstract Algebra*, Narosa Publications
2. I N Herstein, *Topics in Algebra*, Vikas Publications
3. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications
4. D A R Wallace, *Groups, Rings and Fields*, Springer
5. Jones and Jones, *Number Theory*, Springer

Module 2 Analytic Geometry

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, we consider equations of surfaces and curves in three dimensions. It is based on Chapter 12 of the text.

Students have had an introduction to analytic geometry in three dimensions, such as the equations to planes and lines, and to vectors in their Higher Secondary Classes. These must be reviewed with more illustrations. Here the aid of a plotting software becomes essential. The Free Software GNUPLOT mentioned earlier has such 3D capabilities. (see also `http://mathworld.wolfram.com/topics/Surfaces.html`)

After discussing SPHERES and CYLINDRICAL SURFACES as in Section 12.1, We pass on to a discussion of VECTORS, as in Section 12.2. The physical origins of the concept must be emphasized as in the subsection, VECTORS IN PHYSICS AND ENGINEERING. The definition of vector addition can be motivated by the discussion given in the subsection, RESULTANT OF CONCURRENT FORCES which may be familiar to students from their high school physics. All the sections of the chapter are to be discussed in the same spirit, emphasizing both the physical and geometrical interpretations.

Module 3 Calculus

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Here we extend the operations of differentiation and integration to *vector valued functions* of a real variable, based on Chapter 13 of the text.

All sections of this Chapter must be discussed, with emphais on geometry and physics, as in the text. The problems given in various exercise sets should be an essential part of the course. Exercises 17 (a) and 17 (b) of Exercise Set 13.5 on curvature of plane curves and some of its applications in the subsequent exercises must be discussed in detail.

REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.

2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.

3. S.Lang, *A first Calculus*, Springer.

Distribution of instructional hours:

Module 1: 36 hours; Module 2: 27 hours; Module 3: 27 hours

Semester IV

Algebra and Calculus II

CODE: MM 1441 Instructional hours per week: 5

No.of credits: 4

Module I Algebra

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

Continuing the study of rings in the last semester, here we introduce polynomials as another example. This part of the course is based on Chapters 14, 15 and parts of Chapter 16 of the text.

After reviewing the idea of polynomials studied in High School, we introduce polynomials over a commutative ring. The distinction between polynomial as an algebraic expression and polynomial as a function should be emphasized, as in the section POLYNOMIALS AND FUNCTIONS of Chapter 14. All sections of Chapters 14 and 15 are to be discussed.

We then briefly consider irreducible polynomials with real coefficients. After discussing the dependence of irreducibility on the field of coefficients as in the beginning of Chapter 16, we pass on to Section C. The reducibility of polynomials of degree greater than 2 over real numbers must be mentioned, but *Euler's proof for degree 4 need not be discussed*. The fact that the root of a polynomial gives a factor leads to the consideration of roots as in Section E. (*Complex numbers, as in Section D need not be discussed here.*) The origin of complex numbers in the study of cubic equations must be emphasized. (See also, Paul J Nahin, *An Imaginary Tale: The Story of* $\sqrt{-1}$) The unsolvability of higher degree polynomials by radicals, mentioned at the end of this section, must be noted. The FUNDAMENTAL THEOREM OF ALGEBRA must next be discussed. *This theorem need not be proved*, but Euler's real version (COROLLARY 1) must be proved based on this, as in the text.

REFERENCES:

1. J B Fraleigh, *A First Course in Abstract Algebra*, Narosa Publications

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

3. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications

4. D A R Wallace, *Groups, Rings and Fields*, Springer

5. Jones and Jones, *Number Theory*, Springer

Module 2 Calculus

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, we consider the calculus of functions of two variables. It is based on Chapter 14 and Chapter 15 of the text. The geometric interpretation of the ideas should be emphasized throughout, with the aid of plotting software such as Gnuplot.

After a discussion of functions of two variable and their graphs, as in the first section of Chapter 14, we discuss the concepts of limit and continuity of such functions. We then move on to a discussion of differentiation of functions of two variables, as in Sections 14.1–14.3, 14.5 and 14.8–9. *Section 14.4 on differentiability and differentials and Section 14.6 on directional derivatives and Section 14.7 on tangent planes need not be discussed.*

Integration in space is to be done as in Sections 1–5 of Chapter 15. *The last three sections of Chapter 15 need not be discussed.*

References:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. S.Lang, *A first Calculus*, Springer.

Distribution of instructional hours:

Module 1: 36 hours; Module 2: 54 hours

Semester V

Real Analysis I

CODE: MM 1541 Instructional hours per week: 5

No.of credits: 4

Text : R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, Third Edition, Wiley

In this course, we discuss the notion of real numbers and the ides of limits in a formal manner. Many of the topics discussed in this course were introduced somewhat informally in earlier courses, but in this course, the emphasis is on mathematical rigor. It is based on Chapters 2–4 of the text.

In teaching this course, all ideas should be first motivated by geometrical considerations and then deduced algebraically from the axioms of real numbers as a complete ordered field. Also, the historical evolution of ideas, both in terms of physical necessity and mathematical unity should be discussed. Thus the course emphasizes the dialectic between practical utility and logical rigor in general, and within mathematics, that between geometric intuition and algebraic formalism.

Throughout the course, examples and exercises in the text should be used to illustrate the ideas discussed. Students should be encouraged to do problems on their own, to gain practice in writing rigorous proofs.

Module 1

The first step is to make precise the very concept of number and the rules for manipulating numbers. The course can start with a historical overview of how different kinds of numbers were constructed in different periods in history, depending on the physical or mathematical needs of the age. (See for example, the three articles on real numbers at `www-groups.dcs.st-and.ac.uk/~history/Indexes/Analysis.html`) A discussion on how real numbers are conceived as lengths and hence as points on a line should follow this. The efforts to approximate irrational numbers by rational numbers, in the familiar instances such as $\sqrt{2}$ and π can lead to the modern decimal representation and this gives semi-rigorous definitions of operations on real numbers.

The realization of the set $\mathbb{R}$ of real numbers as a field can be introduced at this stage and compared with the set $\mathbb{Q}$ of rational numbers, as in 2.1.1–2.1.4 of the textbook. The idea of order in $\mathbb{Q}$ and $\mathbb{R}$ must be introduced next, as in 2.1.5–2.1.13 of the textbook. The notion of absolute value and that of a neighborhood, as in 2.2.1–2.2.9 of the textbook comes next.

The discussion of the COMPLETENESS PROPERTY OF $\mathbb{R}$ requires some care. The version given in 2.3.6 of the text is highly counter-intuitive as an axiom. Instead, Instead the following version due to Dedekind can be used:

> *If the set of real numbers is split into two non-empty sets such that every number in one set is less than every number in the other, then either the first set contains a least number or the second set contains a largest number*

And this can be easily interpreted geometrically as a line considered as a set of points. (See R. Dedekind, *Essays on The Theory of Numbers*, available as a freely downloadable e-book at `http://www.gutenberg.org/etext/21016`) The SUPREMUM PROPERTY of $\mathbb{R}$ can easily *proved* as a consequence of this axiom.

It should be emphasized at this point that in this course, the only assumptions we make about $\mathbb{R}$ are the axioms of a complete ordered field and every definition we make would be given in terms of these and every result we propose would be deduced from these axioms (and the theorems proved earlier). The remaining part of Section 2.3 and Section 2.4 in full are to be discussed as in the test. *In Section 2.5, the subsections,* THE UNCOUNTABILITY OF $\mathbb{R}$, BINARY REPRESENTATIONS, DECIMAL REPRESENTATIONS, PERIODIC DECIMALS *and* CANTOR'S SECOND PROOF *need not be discussed*.

Module 2

We then pass on to the idea of limits of sequences and series, as in Chapter 3 of the text. It should be supplemented by Sections 10.2 and 10.4 of the calculus text by Anton (used in earlier semesters) to provide motivation, illustrative examples and more exercises.

Module 3

Limits of functions are to be discussed as in Chapter 4 of the text. Before introducing the rigorous definition of limits, the informal description of these ideas through graphs, as done in the earlier calculus courses should be recalled. Also, the various theorems should be illustrated through examples and exercises given in the text. Plotting software such as Geogebra can be used to plot the various functions discussed in Chapter 4.

References

1. A. D. ALEXANDROV et al., *Mathematics:Its Content, Methods and Meaning*, Dover
2. R. DEDEKIND, *Essays on The Theory of Numbers*, available as a freely dowloadable e-book at `http://www.gutenberg.org/etext/21016`)
3. W. RUDIN, *Principles of Mathematical Analysis*, Second Edition, McGraw-Hill
4. A. E. TAYLOR, *General Theory of Functions and Integration*, Dover

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

Semester V

Complex Analysis I

CODE: MM 1542 Instructional hours per week: 4

No.of credits: 3

Text : Joseph Bak and Donald J. Newman, *Complex Analysis*. Third Edition, Springer

In this course, we discuss the basic properties of complex numbers and extend the notions of differentiation and integration to complex functions. It is based on Chapters 1–4 of the text. Examples and exercises in the text forms an integral part of the course.

Module 1

The basic operations on complex numbers are familiar to the students from their Higher secondary course. Also, the historical motivation for complex numbers is briefly touched upon in MODULE 1 of the fourth-semester course ALGEBRA AND CALCULUS IV. So, the present course can start with a brief review of the INTRODUCTION and a discussion on the representation of complex numbers as ordered pairs of real numbers as in Section 1.1. The other sections of this chapters are to be discussed in order. *The definition of uniform convergence and* 1.9 M-TEST *in Section 1.4 need not be discussed. Also,* STEREOGRAPHIC PROJECTION *as in Section 1.5 need not be discussed*, but infinite limits should be introduced (I.11 DEFINITION). The use of complex numbers in number theory and geometry are to be illustrated using Exercises 9, 10 and 14 of this chapter.

We then pass on to the definition of complex functions, starting with polynomials as Chapter 2..The difference between a polynomial function of *two real variables* and that of *a single complex variable* should be emphasized as in the INTRODUCTION to this chapter. Also, in discussing ANOTHER WAY OF RECOGNIZING ANALYTIC POLYNOMIALS preceding 2.2 Definition, it should be noted that the field operations allow us only to define upto *rational functions* of complex numbers and that expressions like $\cos(x + iy)$ are meaningless at this stage. In discussing POWER SERIES as in Section 2.8, *the proof of* 2.8 THEOREM *and the comment following the proof about uniform convergence need not be discussed*. Examples 1–3 following this are to be emphasized as signifying the behaviour of different power series *on* the circle of convergence. The remainig part of Chapter 2 should be discussed in full.

Module 2

In Chapter 3 on ANALYTIC FUNCTIONS, *the proof of 3.2 Proposition on the sufficiency of Cauchy-Riemann Equations for analyticity need not be done*. Except for this, Chapter 3 must be done in full. Exercises 21–23 on the power series expansions of the exponential function and the sine and cosine functions must also be discussed in detail.

Module 3

In Chapter 4, the definition of the integral of f along C (4.3 Definition of the text) should be motivated as limit of the Riemann sums of the form $\sum f(z_k)(z_k - z_{k-1})$ (see for example, the mit OpenCourseWare video of Lecture 5 of Part I Calculus under Calculus Revisited). *In Section 4.1, the result on the integral of uniform limit* (4.11 Proposition) *need not be discussed*. Section 4.2 is to be discussed in full.

References

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

2. J. M. Howie, *Complex Analysis* Springer

Distribution of instructional hours:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

Semester V

Differential Equations

CODE: MM 1543 — Instructional hours per week: 3

No.of credits: 3

Texts : 1. Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

2. Erwin Kreyszig, *Advanced Engineering Mathematics*, Eigth Edition, Wiley-India

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. It is based on parts of Chapters 5 and 9 of [1] and Chapter 2 of [2].

Module 1

In this module we discuss first order equations and is based on [1]. We start with some simple examples of physical situatons in which differential equations arise, using some of the examples of Section 9.3. This is to be followed by the last two subsections of Section 5.2, INTEGRATION FROM THE VIEWPOINT OF DIFFERENTIAL EQUATIONS and DIRECTION FIELDS includeing problems related to these ideas from EXERCISE SET 5.2. We next consider first order differential equations as in Sections 9.1–9.3. Then we discuss EXACT DIFFERENTIAL EQUATIONS as in Section 1.5 of [2].

Module 2

Second order linear differential equations are discussed in this module and it is based on Chapter 2 of [2]. More precisely, Sections 2.1–2.3 and Sections 2.4–2.11 must be done in detail, including relevant problems. *Section 2.3 on* DIFFERENTIAL OPERATORS *need not be discussed*

References

1. G. F. SIMMONS, *Differential Equations with applications and Hystorical notes*, Tata McGraw-Hill, 2003

2. PETER V. O' NEIL, *Advanced Engineering Mathematics*, Thompson Publications, 2007

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

Semester V

Vector Analysis

CODE: MM 1544 — Instructional hours per week: 3

No.of credits: 3

Text : Howard Anton, et al, *Calculus*, 7$^{\text{th}}$ Edn, John Wiley

In this course, we consider some advanced parts of vector calculus. It is based on parts of Chapter 14 and Chapter 16 of the text. The physical motivation and interpretation of the various mathematical concepts should be emphasized throughout, as in the text.

Module 1

We begin with the notion of directional derivatives as in Section 14.6. *The last subsection on derivative of a function of several variables need not be discussed*. We then pass on to the definition of a vector field and its divergence and curl, as in Section 16.1. The del and Laplacian operators must also be discussed. We next discuss line integrals, as in Section 16.2 and then conservative vector fields, as in Section 16.3. This module of the course ends with a discussion of Green's Theorem, as in Section 16.4.

Module 2

In this module, we introduce the notion of a surface integral and discuss Gauss's Theorem and Stoke's Theorem and their applications, as in Sections 16.5–16.8 of the text

References:

1. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
2. Kreyzig, *Advanced Engineering Mathematics*, 8^{th} edition, John Wiley.
3. Peter V. O' Neil, *Advanced Engineering Mathematics*, ThompsonPublications, 2007
4. Michael D. Greenberg, *Advanced Engineering Mathematics*, PearsonEducation, 2002.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

Semester V

Abstract Algebra I

CODE: MM 1545 Instructional hours per week: 5

No.of credits: 4

Text : John B. Fraleigh, *A First Course in Abstract Algebra*. Seventh Edition, Narosa

Students introduced to some elements of Abstract Algebra in Semester IV are now ready to do it rigorously. In this course, we discuss the basics of abstract group theory, based on Sections 2–10 of the text.

Students should be given training to write proofs and to do problems, based on axioms. The recommended text contains lots of examples and exercises. Most of the problems in this text are computational and hence the student can try them as assignments with proper guidance of the teacher.

Module 1

The course begins with section 0, which can be reviewed quickly. *The subsection on* CARDINALITY *need not be discussed*. We then move on to Section 2 on binary relations (*skipping Section 1*. The ideas of *binary operation on a set*, *well definedness of a binary operation* and *a set closed under a binary operation* should be emphasized. Isomorphisms of binary structures should be done in detail, as in Section 3. After recalling the idea of abstract groups introduced in the previous semester, Section 4 on groups, Section 5 on subgroups and Section 6 on cyclic groups must be done in full. *Section 7,* GENERATING SETS AND CAYLEY DIGRAPHS, *need not be discussed*.

Module 2

We next consider the group of permutations in detail, as in Section 8–10 (Chapter II) and cosets and Lagrange's Theorem, as in Section 10. The first part of Section 11 on direct products of groups should also be discussed. *The second part,* FINITELY GENERATED ABELIAN GROUPS *and the entire Section 12,* PLANE ISOMETRIES *need not be discussed*.

REFERENCES:

1. I N Herstein, *Topics in Algebra*, Vikas Publications

2. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications

3. D A R Wallace, *Groups, Rings and Fields*, Springer

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 45 hours; Module 2: 45 hours

Semester V

Operations Research (Open Course)

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

Module 1 LINEAR PROGRAMMING: 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 2 TRANSPORTATION PROBLEMS: 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 3 PROJECT MANAGEMENT: Activity -dummy activity - event - project network, CPM (solution by network analysis only), PERT.

TEXT: Ravindran - Philps - Solberg: Operations Research- Principles and Practice

REFERENCE:

Hamdy A Taha: *Operations Research*

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

Semester V

Business Mathematics (Open Course)

CODE: MM 1551.2

Instructional hours per week: 3
No. of Credits: 2

Module 1 Basic Mathematics of Finance: Nominal rate of Interest and effective rate of interest, Continuous Compounding, force of interest, compound interest calculations at varying rate of interest, present value, interest and discount, Nominal rate of discount, effective rate of discount, force of discount, Depreciation.

(Chapter 8 of Unit I of text- Sections: 8.1, 8.2, 8.3, 8.4. 8.5, 8.6, 8.7, 8.9)

Module 2 Differentiation and their applications to Business and Economics: Meaning of derivatives, rules of differentiation, standard results (basics only for doing problems of chapter 5 of Unit 1) (Chapter 4 of unit I of text- Sections: 4.3, 4.4, 4.5, 4.6)

Maxima and Minima, concavity, convexity and points of inflection, elasticity of demand, Price elasticity of demand (Chapter 5 of Unit I of text - Sections: 5.1, 5.2, 5.3, 5.4, 5.5. 5.6, 5.7)

Integration and their applications to Business and Economics: Meaning, rules of integration, standard results, Integration by parts, definite integration (basics only for doing problems of chapter 7 of Unit 1 of text) (Chapter 6 of unit I of text: Sections: 6.1, 6.2, 6.4, 6.10, 6.11)

Marginal cost, marginal revenue, Consumer's surplus, producer's surplus, consumer's surplus under pure competition, consumer's surplus under monopoly (Chapter 7 of unit I of text- Sections: 7.1, 7.2, 7.3, 7.4, 7.5)

Module 3 Index Numbers: Definition, types of index numbers, methods of construction of price index numbers, Laspeyer's price index number, Paasche's price index number, Fisher ideal index number, advantages of index numbers, limitations of index numbers

(Chapter 6 of Unit II of text- Sections: 6.1, 6.3, 6.4, 6.5, 6.6, 6.8, 6.16, 6.17)

Time series: Definition, Components of time series, Measurement of Trend (Chapter 7 of Unit II of text - Sections: 7.1, 7.2, 7.4)

TEXT: B M Aggarwal: Business Mathematics and Statistics Vikas Publishing House, New Delhi, 2009

REFERENCES:

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

2. Alpha C Chicny, Kevin Wainwright: *Fundamental methods of Mathematical Economics* ,Mc-Graw Hill, Singapre, 2005

Distribution of instructional hours:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

Semester V

Actuarial Science (Open Course)

CODE: MM 1551.3 — Instructional hours per week: 3
No. of Credits: 2

Module 1 : Introduction to Insurance Business: What is Actuarial Science? Concept of Risk, Role of statistics in Insurance, Insurance business in India.

Introductory Statistics: Some important discrete distributions, Some important continuous distributions, Multivariate distributions

Module 2 : Feasibility of Insurance business and risk models for short terms: Expected value principle, Notion of utility,risk models for short terms

Future Lifetime distribution and Life tables: Future life time random variable, Curate future-life time, life tables, Assumptions for fractional ages, select and ultimate life tables.

Module 3 : Actuarial Present values of benefit in Life insurance products: Compound interest, Discount factor, Benefit payable at the moment of death, Benefit payable at the end of of year of death, relation between A and $\bar{A}$.

Annuities, certain, continuous life annuities, Discrete life annuities, Life annuities with m^{th}ly payments.

TEXT: Shylaja R. Deshmukh : Actuarial Statistics University press, Hyderabad, 2009. Chapters 1 - 6.

REFERENCES:

1. Bowers, Jr., N. L et al: *Actuarial Mathematics* , 2^{nd} Edition,The society of Actuaries, Illinois, Sahaumberg,1997

2. Palande, P. S. et al: *Insurance in India: Changing policies and Emerging Oppertunities* ,Response Books, New Delhi, 2003

3. Purohit, S. G. et al: *Statistics Using R* ,Narosa, New Delhi, 2008

4. www.actuariesindia.org

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 12 hours; Module 2: 21 hours; Module 3: 21 hours

Semester VI

Real Analysis II

CODE: MM 1641 Instructional hours per week: 5

No.of credits: 4

Text : R. G. Bartle, D. R. Sherbert, *Introduction to Real Analysis*, Third Edition, Wiley

This course builds on the first course in Real Analysis done earlier and concentrates on real valued functions. We discuss the three properties of continuity, differentiability and Riemann integrability. The history of how calculus developed must also be discussed (see `en.wikipedia.org/wiki/History_of_calculus`, for example).

Module 1

The intuitive geometric notion of continuity as an unbroken curve seen in the calculus course must be recalled and then the discussion should gradually lead to the ϵ-δ definition, as an effort to make this notion formal and rigorous. The connexion between continuity and existence of limit should be emphasized. The material contained in Sections 5.1–5.3 and Section 5.6 of the textbook forms the core of this part of the course. *Section 5.4,* UNIFORM CONTINUITY *and Section 5.5,* CONTINUITY AND GAUGES, *need not be discussed.*

Module 2

Differentiation and integration are extensively discussed in an earlier Calculus course, with a strong emphasis on computation. Here we take another look at differentiation from a conceptual point of view. It is based on Chapter 6 of the textbook. All the four sections of this chapter are to be discussed in detail.

Module 3

In this module, we discuss Riemann's theory of integration. It is based on Sections 7.1–7.3 of the text. *Section 7.4,* APPROXIMATE INTEGRATION *need not be discussed.*

Students have already seen integration as anti-differentiation and informally as the limit of sums in the calculus couse. All these idea are made more precise here. The historical evolution of the ideas leading to Riemann integral can be found in `en.wikipedia.org/wiki/Integral#History`. The differences between anti-differentiation and Riemann's theory of integration should be stressed. Section 7.3 of the textbook must be seen as establishing the links between anti-differntiation and Riemann integration, Examples 7.3.2(e) and 7.3.7(a), (b) are significant in this context.

References

1. A. D. Alexandrov et al., *Mathematics:Its Content, Methods and Meaning*, Dover

2. R. Dedekind, *Essays on The Theory of Numbers*, available as a freely dowloadable e-book at `http://www.gutenberg.org/etext/21016`)

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

4. A. E. Taylor, *General Theory of Functions and Integration*, Dover

Distribution of instructional hours:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

Semester VI

Linear Algebra

CODE: MM 1642 | Instructional hours per week: 4

No.of credits: 3

Text : Thoma Banchoff and John Wermer, *Linear Algebra Through Geometry*, Second Edition, Springer

In this course we introduce the basics of linear algebra and matrix theory with emphasis on their geometrical aspects. It is based on the Chapters 1–4 of the text.

Module 1

In this module we bring together some aspects of analytic geometry of two dimensions, solutions of simultaneous in two unknowns and theory of 2×2 matrices under the unified theme of linear transformations of the plane. It is based on Chapters 1 and 2 of the text.

Module 2

The ideas in the first module are extended to three dimensional space in this module. It is based on Chapter 3 of the text

Module 3

The concepts discussed in the first two modules are generalized to arbitrary dimensions in this module. It is based on Chapter 4 of the text.

TEXT: References:

1. T S Blyth and E F Robertson: *Linear Algebra*, Springer, Second Ed.
2. R Bronson and G B Costa: *Linear Algebra*, Academic Press, Seond Ed.
3. David C Lay: *Linear Algebra*, Pearson
4. K Hoffman and R Kunze: *Linear Algebra*, PHI

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

Semester VI

Complex Analysis II

CODE: MM 1544 | Instructional hours per week: 3

No.of credits: 3

Texts 1. Joseph Bak and Donald J. Newman, *Complex Analysis.* Third Edition, Springer

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

In this course, we consider some of the basic properties of functions analytic in a disc or on a punctured disc. It is based on parts Chapters 6, 9, 10, 11 of [1] and Chapters 6 and 7 of [2].

Module 1

We start with Sections 6.1 and 6.2 of [1]. In Section 6.1, *only the statement of* 6.5 POWER SERIES REPRESENTATION FOR FUNCTIONS ANALYTIC IN A DISC *need be given; the proof need not be discussed*. But it should be linked to 2.10 COROLLAY to note that a function analytic in a disc is infinitely differentiable in it and with 2.11 COROLLARY to see how the coefficients of the series are related to the derivatives of the function. *Section 6.3 need not be discussed.*

We then pass on to a discussion of isolated singular points and residues, as in Chapter 6 (Sections 68–77). *Here and elsewhere, all examples and exercises involving logarithms must be skipped.*

Module 2

In this module, we consider the application of the Residue Theorem in the evaluation of some integrals. as in Chapter 7 of [2]. Only Sections 78–82 and Section 85 need be discussed. *Sections 83–84 and Sections 86–89 need not be considered.*

Section 11.2 of [1], APPLICATION OF CONTOUR INTEGRAL METHODS TO EVALUATION AND ESTIMATION OF SUMS, must also be discussed, along with the relevant exercises in this section.

REFERENCES:

1. Ahlfors, L. V, *Copmlex Analysis*, McGraw-Hill, 1979.
2. J M Howie, *Complex Analysis*, Springer

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

Semester VI

Abstract Algebra II

CODE: MM 1544 Instructional hours per week: 3

No.of credits: 3

TEXT: John B. Fraleigh, *A First Course in Abstract Algebra*. Seventh Edn, Narosa

In this course, we discuss more of group theory and also the basics of ring theory. It is based on parts of Chapters II–V of the text. As in the first course, due emphasis must be given to problem solving.

Module 1

In this part of the course, we discuss homomorphism of groups and factor groups, as in Sections 13–15 of the text. *The last two parts of Section 15,* SIMPLE GROUPS *and* THE CENTER AND COMMUTATOR SUBGROUPS *need not be discussed.*.

Module 2

We start by recalling the definition of rings, seen in an earlier course on algebra. Then Sections 18-20 must be discussed in detail. *Sections 21–25 need not be discussed*, But Section 26 on homomorphisms and factor rings must be done in full.
REFERENCES:

1. I N Herstein, *Topics in Algebra*, Vikas Publications
2. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications
3. D A R Wallace, *Groups, Rings and Fields*, Springer

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

Semester VI

Computer Programming

CODE: MM 1541 — Instructional hours per week: 5

No.of credits: 4

In this course, we teach document preparation in computers using the LaTeX typesetiing program and also the basics of computer programming using Python. Since the operatig system to be used is GNU/Linux, fundamentals of this OS are also to be discussed.

Module 1

Text : Matthias Kalle Dalheimer and Matt Welsh, *Running Linux*, Fifth Edition, O'Reilly

In this module, we consider the fundamentals of the GNU/Linux operating system. It is based on Chapter 4, BASIC UNIX COMMANDS AND CONCEPTS, of the text. Students should be taught about the Linux directory structure and the advantages of keeping their files in well structured directories. Since they will be using the command line interface most of the time, this entails facility in using such commands as `mkdir`, `pwd`, `cd`, `ls`, `cp`, `mv`, `ls` and so on.

Module 2

Text : *LaTeX Tutorials—A Primer* by Indian TeX Users Group

In this module, we discuss computer typesetting using LaTeX, Chapters 1–2 of the text must be discussed in full. On bibliography, only the first section of Chapter 3 need be discussed. Also, only the first section of Chapter 4—on table of conetents–need be done. Chapters 6–9 are to be done in full. Finally Chapter 12 also is to be discussed in full.

Module 3

Text : Vernon L. Ceder, *The Quick Python Book*, Second Edition, Manning

It is based on Chapters 3–9 of the text. The concepts in Chapters 3–8 must be discussed in full, but in Chapter 9, only Sections 9.1–9.5 need be discussed.

The programs done in class should all have a mathematical content. SOme possibilities are listed below:

- Factorial of a number
- Checking primality of a number

- Listing all primes below a given number
- Prime factorization of a number
- Finding all factors of a number
- GCD of two numbers using the Euclidean Algorithm
- Finding the multiples in Bezout's Identity

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

Semester VI

Graph Theory (Elective)

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

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 1 A brief history of Graph Theory: The Königsberg bridge problem, the history of the Four Colour Theorem for maps, Contributions to Graph Theory by Euler, Kirchoff, Cayley, Mobius, De Morgan, Hamilton, Erdös, Tutte, Harary, etc. (A maximum of three hours may be allotted to this sub-module. In addition to sections 1.2 and 1.6 of the text, materials for this part can be had from other sources including the internet.)Graphs: Definition of graph, vertex, edge, incidence, adjacency, loops, parallel edges, simple graph. Representation of graphs, diagrammatic representation, matrix representation (adjacency* matrix and incidence matrix only). Finite and infinite graphs, Definition of directed graphs, illustrative examples, Directed graphs, Applications of graphs. [sections 1.1, 1.2, 1.3, 1.4, 7.1, 9.1, 9.2]Degree of a vertex, odd vertex, even vertex, relation between sum of degrees of vertices and the number of edges in a graph, and its consequence: number of odd vertices in a graph is even. Isolated vertex, pendant vertex, null graph, complete graphs [page 32], bipartite graphs [page 168], complete bipartite graph [page 192-prob 8.5], regular graph, complement* of a graph, graph isomorphisms, self complementary* graphs, illustrative examples. [sections 1.4, 1.5, 2.1]Sub-graphs, edge disjoint sub-graphs, spanning sub-graphs*, induced subgraphs [sections 2.2]The decanting problem and its graph model [no solution at this point]. The puzzle with multicolour cubes [problem 1.8 and section 2.3].

Module 2 Walks, open walks, closed walks, paths, circuits, end vertices of a path, path joinig two vertices, length of a path, connected and disconnected graphs. Components of a graph. [sections 2.4, 2.5]Euler line, Euler graph, unicursal line, unicursal graph, characterisaion of Euler graph, Concept of Euler digraph [section 2.5, 9.5], Solution of the decanting problem. The Königsberg problem, the Chinese postman problem* and the Teleprinter's problem, their graph models and solutions. [problem 1.8 and sections 2.3, 1.2, 9.5]

Module 3 Trees- properties of trees, distance, eccentricity, center, radius, diameter, spanning tree, illustrative examples. [sections 3.1, 3.2, 3.3, 3.4, 3.7]Planar graphs examples of planar and non-planar graphs, different representations of a planar graph. Regular polyhedra, Euler's polyhedral formula. [Theorem 5.6, without proof] .

Illustrative examples, Kuratowski's graphs and their importance in the theory of planar graphs, forbidden sub-graph,

characterisaion of planar graph [Kuratowski's theorem, Theorem 5.9, without proof], illustrative examples-both planar and non-planar. [sections 5.2, 5.3, 5.4, 5.5] Graph theoretic version of the Four Colour Theorem, without proof.

TEXT: Narsingh Deo: Graph Theory with applications for Engineering and Computer Science, Prentice Hall of India Pvt. Ltd., 2000.
References:

1. BalakrishnanR and Ranganatahan: *A Text Book of Graph Theory*, Springer
2. Body J A and Murthy U S R:*Graph Theory with Applications*, The Macmillan Press
3. Harary F: *Graph Theory*, Addison-Wesley
4. Vasudev C: *Graph Theory with Applications*
5. West D B: *Introduction to Graph Theory*, Prentice Hall of India Pvt. Ltd.

Note: Generally, the references are from NARSINGH DEO. Those marked with an asterisk are found elsewhere.DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

Semester VI

Fuzzy Mathematics (Elective)

CODE: MM 1661.2

Instructional hours per week: 3
No. of credits: 2

Module 1 FROM CRISP SETS TO FUZZY SETS: A PARADIGM SHIFT.Introduction-crisp sets: an overview-fuzzy sets: basic types and basic concepts of fuzzy sets, Fuzzy sets versus crisp sets, Additional properties of cuts, Representation of fuzzy sets.

Module 2 OPERATIONS ON FUZZY SETS AND FUZZY ARITHMETIC:Operations on fuzzy sets-types of operations, fuzzy complements, fuzzy intersections, t-norms, fuzzy unions, t-conorms.

Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals, Arithmetic operations on fuzzy numbers.

Module 3 FUZZY RELATIONS :Crisp versus fuzzy relations, projections and cylindric extensions, Binary fuzzy relations, Binary relations on a single set, Fuzzy equivalence relations.

TEXT: George J Klir and Yuan: Fuzzy sets and fuzzy logic: Theory and applications, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
Chapter 1: Sections 1.1 to 1.4
Chapter 2: Sections 2.1 and 2.2
Chapter 3: Sections 3.1 to 3.4
Chapter 4: Sections 4.1 to 4.4
Chapter 5: Sections 5.1 to 5.5

References:

1. Klir G J and T Folger: *Fuzzy sets, Uncertainty and Information*, PHI Pvt.Ltd., New Delhi, 1998

2. H J Zimmerman: *Fuzzy Set Theory and its Applications*, Allied Publishers, 1996.

3. Dubois D and Prade H: *Fuzzy Sets and Systems: Theory and Applications*, Ac.Press, NY, 1988.

Distribution of instructional hours:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

Semester VI

Mechanics (Elective)

CODE: MM 1661.3 — Instructional hours per week: 3
No. of credits: 2

Part A: STATICS

Module 1 Introduction, composition and resolution of forces, parallelogram law of forces, triangle law of forces, Lami's theorem, polygon of forces, $\lambda-\mu$ theorem, resultant of a finite number of coplanar forces acting upon a particle, conditions of equilibrium, parallel forces, resultant of two parallel forces acting upon a rigid body, moments, moments of a force about a point and about an axis, generalized theorem of moments.

Module 2 Couples, equilibrium of a rigid body acted on by three coplanar forces, general conditions of equilibrium of a rigid body under coplanar forces, friction, laws of friction, limiting friction, coefficient of friction and simple problems.

Part B : DYNAMICS

Module 3 Velocity, relative velocity, acceleration, parallelogram laws of acceleration, motion under gravity, Newtons laws of motion and their applications to simple problems. Impulse, work, energy, kinetic and potential energies of a body, principle of conservation of energy.

Module 4 Projectiles, Range on an inclined plane, Collision of elastic bodies, Newton's experimental law, Impact of sphere on a plane, Direct and oblique impact of two spheres, Loss of kinetic energy by impact, Simple harmonic motion, Examples of simple harmonic motion, Simple pendulum.

TEXT: by S.L. Loney, The Elements of Statics and Dynamics, Part-I and Part-II, AITBSPublications and distributions (Regd), Delhi
Distribution of instructional hours:

Module 1: 15 hours; Module 2: 12 hours; Module 3: 15 hours, Module 4: 12 hours

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

Semester I

Mathematics-I
(Differentiation and Analytic Geometry)
Code: MM 1131.1

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

Overview
The complementary course intended for Physics students lays emphasis on the application of mathematical methods to Physics. The two modules on Calculus links the topic to the real world and the student's own experience as the authors of the text put it. Doing as many of the indicated exercises from the text should prove valuable in understanding the applications of the theory. Analytic geometry presented here is important in applications of calculus.

Module 1: Differentiation with applications to Physics-I

- Functions and graphs of functions with examples from Physics. Interpretations of slope. The graph showing direct and inverse proportional variation. Mathematical models (functions as models). Parametric equations. Cycloid and Brachistochrone problem.
  Exercise set 1.8; Questions 31 - 34, 37 and 39.

- Instantaneous velocity and the slope of a curve. Limits. Infinite limits and vertical asymptotes. Limits at infinity and horizontal asymptotes. Some basic limits.
  Exercise set 2.1; Questions 27 and 28.

- Continuity. Slopes and rates of change. Rates of change in applications. Derivative.
  Exercise set 3.1; Questions 1 - 4 and 15, 16, 18 - 21.
  Exercise set 3.2; Question 39.

- Techniques of differentiation. Higher derivatives. Implicit differentiation. Related rates. Local linear approximation. Differentials.
  Examples 1 - 6.
  Exercise set 3.3; Question 68.
  Exercise set 3.4; Question 32.
  Exercise set 3.8; Questions 57 - 60.

- Rectilinear motion. Speeding up and slowing down. Analysing the position versus time curve. Free fall motion.
  Examples 1 - 7. Exercise set 4.4; Questions 8, 9, 23, 27, 30 - 32.

- Absolute maxima and minima. Applied maximum anmd minimimum problems.
  Exercise set 4.6; Questions 47, 48, 56, 59.

- Statement of Rolle's Theorem and Mean Value Theorem. The velocity interpretation of Mean Value Theorem. Statement of theorems 4.1.2 and 4.83 (consequences of the Mean Value Theorem).
  Exercise set 4.8; Questions 22 - 25.

- Inverse functions. Continuity and differentiability of inverse functions. Graphing inverse functions. exponential and logarithmic functions. Derivatives of logarithmic functions and logarithmic differentiation. Derivatives of the exponential function. Graphs and applications involving logarithmic and exponential functions. Logistic curves. Example 4 of section 7.4 (Newton's Law of Cooling).
  Exercise set 7.4; Questions 31, 35, 49 - 50.

- Definitions of hyperbolic functions. Graphs of hyperbolic functions. Hanging cables and other applications. Hyperbolic identities. Why they are called hyperbolic functions. Derivatives of hyperbolic functions. Inverse hyperbolic functions. Logarithmic forms of inverse hyperbolic functions. Derivatives of inverse hyperbolic functions.
  Exercise set 7.8; Questions 69 and 72.

Module 2: Differentiation with applications to Physics-II

- Power series and their convergence. Results about the region of convergence of a power series(without proof). Radius of convergence. Functions defined by a power series. Results about term by term differentiation and integration of power series (without proof). Taylor's theorem with derivative form of remainder (without proof) and its use in approximating functions by polynomials. Taylor series and Maclaurin series and representation of functions by Taylor series. Taylor series of basic functions and the regions where these series converge to the respective functions. Binomial series as a Taylor series and its convergence. Obtaining Taylor series representation of other functions by differentiaion, integration, substitution etc.

- Functions of several variables. Graphs of functions of two variables. Equations of surfaces such as sphere, cylinder, cone, paraboloid, ellipsoid, hyperboloid etc. Partial derivatives and differentials. The chain rule (various forms). Euler's theorem for homogeneous functions. Jacobians.
  Exercise set 14.3; Questions 47 and 48.
  Exercise set 14.4; Questions 49 and 50.
  Exercise set 14.5; Questions 41. 42 and 46.

- Local maxima and minima of functions of two variables. Use of partial derivatives in locating local maxima and minima. Lagrange method for finding maximum/minimum values of functions subject to one constraint.
  Exercise set 14.9; Question 20.

Module 3: Analytic Geometry

- Geometric definition of a conic-the focus, directrix and eccentricity of a conic. Classification of conics into ellipse, parabola and hyperbola based on the value of eccentricity. Sketch of the graphs of conics. Reflection properties of conic sections.
  Exercise set 11.4; Questions 39 - 43.

- Equations of the conics in standard positions. Equations of the conics which are translated from standard positions vertically or horizontally. Parametric representation of conics in standard form. Condition for a given straight line to be a tangent to a conic. Equation of the tangent and normal to a conic at a point.
- Asymptotes of a hyperbola. Equation of the asymptotes.
- Conic sections in polar coordinates. Eccentricity of an ellipse as a measure of flatness. Polar equations of conics. Sketching conics in polar coordinates. Kepler's Laws.

  Example 4 of section 11.6.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Semester II

Mathematics-II
(Integration and Vectors)

Code: MM 1231.1

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

Overview

The complementary course in the second semester continues the trend indicated in the first, namely, laying emphasis on applications of integral calculus and vectors to problems in Physics. Module 1 consists of various applications of integration techniques. It also covers multiple integrals. Modules 2 and 3 deal with vector calculus and its applications in detail.

Module 1: Applications of integration

- Integral curves, integration from the view point of differential equations, direction fields
  Exercise set 5.2; Questions 43, 44 and 51.
- Rectilinear motion: finding position and velocity by integration. Uniformly accelerated motion. The free-fall model. integrating rates of change. Displacement in rectilinear motion. Distance travelled in rectilinear motion. Analysing the velocity versus time curve. Average value of a continuous function. Average velocity revisited.
  Exercise set 5.7; Questions 3, 4, 5, 6, 29, 39, 45 and 55.
- Use of definite integrals in finding area under curves, area between two curves, volume of revolution, arc length and surface area of a solid of revolution.
- The idea of approximating the volume under a bounded surface in 3-space by volumes of boxes, leading to the definition of double integrals of functions of two variables over bounded regions. Evaluation of double integrals by iterated integrals. Evaluation by changing to polar co-ordinates and by suitably changing order of integration in the iterated integral. Applications to finding the volume of solids under bounded surfaces.

- Triple integrals over bounded regions in three space. Evaluation by iterated integrals. Cylindrical coordinates and spherical coordinates and their relation to Cartesian coordinates. Use of cylindrical and spherical co-ordinates in evaluating triple integrals. Applications of triple integrals to finding volumes of solid objects.

Module 2: Vector Differentiation

- Vector function of a single variable and representation in terms of standard basis. Limit of a vector function and evaluation of limit in Cartesian representation. Continuous vector functions and the idea that such functions represent oriented space curves. Examples.
- Derivative of a vector function and its geometric significance. Derivative in terms of Cartesian components. Tangent vector to a curve, smooth and piecewise smooth curves. Applications to finding the length and curvature of space curves, velocity and acceleration of motion along a curve etc.
- Scalar field and level surfaces. The gradient vector of a scalar field (Cartesian form) at a point and its geometric significance. Gradient as an operator and its properties. Directional derivative of a scalar field and its significance. Use of gradient vector in computing directional derivative.
- Vector fields and their Cartesian representation. Sketching of simple vector fields in the plane. The curl and divergence of a vector field(Cartesian form) and their physical significance. The curl and divergence as operators, their properties. Irrotational and solenoidal vector fields. Various combinations of gradient, curl and divergence operators.

Module 3: Vector Integration

- The method of computing the work done by a force field in moving a particle along a curve leading to the definition of line integral of a vector field along a smooth curve. Scalar representation of line integral. Evaluation as a definite integral. Properties. Line integral over piecewise smooth curves. Green's theorem in the plane (without proof) for a region bounded by a simple closed piecewise smooth curve.
- Oriented surfaces. The idea of flux of a vetor field over a surface in 3-space. The surface integral of a vector field over a bounded oriented surface. Evaluation by reducing to a double integral. Use of cylindrical and spherical co-ordinates in computing surface integral over cylindrical and spherical surfaces.
- Stokes' theorem (without proof) for an open surface with boundary a piecwise smooth closed curve. Gauss' divergence theorem (without proof). Verification of the theorems in simple cases and their use in computing line integrals or surface integrals which are difficult to evaluate directly. Physical intrepretation of divergence and curl in terms of the velocity field of a fluid flow.
- Conservative fields and potential functions. Relation of conservative vector fields to their irrotational nature and the path- independence of line integrals in the field (without proof). Significance of these results in the case of conservative force fields such as gravitational, magnetic and electric fields. Method of finding the potential function of a conservative field.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Semester III

Mathematics-III
(Differential Equations, Theory of Equations and Theory of Matrices)

Code: MM 1331.1

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

Module 1: Differential equations

- Review of basic concepts about differential equations and their solutions. Method of solving special types of first order ODEs such as variable separable, exact, homogeneous, and linear. Finding the family of curves orthogonal to a given family.
- Second order linear differential equations. Nature of the general solution of homogeneous and non-homogeneous linear ODEs. Extension to higher order ODE.
- Second order linear homogeneous ODEs with constant coefficients. The characteristic equation and its use in finding the general solution. Extension of the results to higher order ODEs.
- Second order linear non-homogeneous ODEs with constant coefficients. General solution as the sum of complementary function and particular integral. Second order linear differential operator and its properties. The inverse operator and its properties. Operator method for finding the particular integral of simple functions. Extension of the results to higher order equations. Cauchy and Legendre equations and their solutions by reducing to equations with constant coefficients by suitable change of variable.

Module 2: Linear Algebra

- The rows and columns of a matrix as elements of $\mathbb{R}^n$ for suitable n. Rank of a matrix as the maximum number of linearly independent rows/columns. Elementary row operations. Invariance of rank under elementary row operations. The echelon form and its uniqueness. Finding the rank of a matrix by reducing to echelon form.
- Homogeneous and non-homogeneous system of linear equations. Results about the existence and nature of solution of a system of equations in terms of the ranks of the matrices involved.
- The eigen value problem. Method of finding the eigen values and eigen vectors of a matrix. Basic properties of eigen values and eigen vectors. Eigen values and eigen vectors of a symmetric matrix.
- Diagonalisable matrices. Advantages of diagonalisable matrices in computing matrix powers and solving system of equations. The result(without proof) that a square matrix of order n is diagonalisabe (i) if and only if it has n linearly independent eigen vectors (ii) if it has n distinct eigen values. Method of diagonalising a matrix. Diagonalisation of real symmetric matrices. Similar matrices.

Module 3: Theory of Equations

- Fundamental theorem of Algebra (without proof), relations between roots and coefficients of a polynomial, finding nature of roots of polynomials without solving-Des Cartes' rule of signs, finding approximate roots via bisection method, Newton-Raphson method

Text for Module 1: Kreyzig, Advanced Engineering Mathematics, 8^{th} edition, John Wiley.
Text for Module 2:Peter V. O' Neil, Advanced Engineering Mathematics, Thompson Publications, 2007
Text for Module 3: Barnard and Child, Higher Algebra, Macmillan
Advanced Engineering Mathematics, K A Stroud, 4th Edition, Palgrave, 2003

Semester IV

Mathematics-IV
(Complex Analysis, Fourier Series and Fourier Transforms)

Code: MM 1431.1

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

Module 1: Complex Analysis

- Representation of complex numbers, operations involving them, conjugates, polar form of complex numbers, De-Moivre's formula, complex number sets and functions, their limit, continuity, derivatives. Analytic functions, Cauchy-Riemann equations and Laplace equation, harmonic functions, proof that an analytic function with constant modulus is constant, exponential, trigonometric, hyperbolic,logarithmic functions in $\mathbb{C}$
- Complex integration: Line integral (definition only, proof on existence not required), section on bounds on line integrals may be omitted, Cauchy's integral theorem and formula, and problems involving them, connected, multiply connected domains, Cauchy's inequality, Liouville's theorem, Morera's theorm (all without proof), problems using the theorems
- Complex sequences, series, their convergence tests, problems using the tests, power series and their convergence, radius of convergence of power series, addition, multiplication of power series, power series representation of analytic functions, Taylor, MacLaurin's series approximations, problems to find the series representations of important functions
- Laurent series of functions, its singularities, poles, and zeros, Cauchy's resdue integration method, findin residues, residue theorem (without proof), problems and applications using it

Module 2: Fourier series and transforms

- Periodic functions, trigonometric series, Fourier series, evaluation of Fourier coefficients for functions defined in $(-\infty, +\infty)$, Fourier series for odd and even functions, half range series, Fourier series for odd and even functions, Fourier series of functions defined in $(-L, +L)$.

- Fourier integrals and Fourier transforms.

Text:Kreyzig, Advanced Engineering Mathematics, 8^{th} edition, John Wiley.

References

1. Thomas and Finney, Calculus and Analytic Geometry, Ninth Edition, Addison–Wesley.

2. Michael D. Greenberg, Advanced Engineering Mathematics, Pearson Education, 2002.

3. James Stewart, Essential Calculus, Thompson Publications, 2007.

4. David C. Lay, Linear Algebra, Thompson Publications, 2007.

5. George F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, 2003

6. T. Gamelin, Complex Analysis, Springer-verlag, 2006

7. Brown and Churchil, Complex Variables and Applications, McGraw-Hill Higher Education; 8 edition, 2008

8. S L Loney, The elements of coordinate geometry

9. SAGE Math official website http://www.sagemath.org/

10. Gnuplot official website containing documentation and lot of examples http://www.gnuplot.info/

11. More help and examples on gnuplot http://people.duke.edu/ hpgavin/gnuplot.html

12. Maxima documentations http://maxima.sourceforge.net/documentation.html

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

Semester I

Mathematics-I
(Differentiation and Matrices)
Code: MM 1131.2

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

Overview
The complementary course intended for Chemistry students lays emphasis on the application of mathematical methods to Chemistry. The two modules on Calculus links the topic to the real world and the student's own experience as the authors of the text put it. Doing as many of the indicated exercises from the text should prove valuable in understanding the applications of the theory. The third module covers matrix theory.

Module 1: Differentiation with applications to Chemistry-I

- Functions and graphs of functions with examples from Chemistry. Interpretations of slope. The graph showing direct and inverse proportional variation. Mathematical models (functions as models). Parametric equations. Cycloid and Brachistochrone problem.
  Exercise set 1.8; Questions 31 - 34.
- Instantaneous velocity and the slope of a curve. Limits. Infinite limits and vertical asymptotes. Limits at infinity and horizontal asymptotes. Some basic limits.
  Exercise set 2.1; Questions 27 and 28.
- Continuity. Slopes and rates of change. Rates of change in applications. Derivative.
  Exercise set 3.1; Questions 1,2 and 16.
- Techniques of differentiation. Higher derivatives. Implicit differentiation. Related rates. Local linear approximation. Differentials.
  Exercise set 3.8; Questions 53 - 55.
- Rectilinear motion. Speeding up and slowing down. Analysing the position versus time curve. Free fall motion.
  Examples 1 - 7. Exercise set 4.4; Questions 8, 9, 30 - 32.
- Absolute maxima and minima. Applied maximum and minimimum problems.
  Exercise set 4.6; Questions 47 and 48.
- Statement of Rolle's Theorem and Mean Value Theorem. The velocity interpretation of Mean Value Theorem. Statement of theorems 4.1.2 and 4.83 (consequences of the Mean Value Theorem).

- Inverse functions. Continuity and differentiability of inverse functions. Graphing inverse functions. exponential and logarithmic functions. Derivatives of logarithmic functions and logarithmic differentiation. Derivatives of the exponential function. Graphs and applications involving logarithmic and exponential functions.
  Exercise set 7.4; Question 50.

- Definitions of hyperbolic functions. Graphs of hyperbolic functions. Hyperbolic identities. Why they are called hyperbolic functions. Derivatives of hyperbolic functions. Inverse hyperbolic functions. Logarithmic forms of inverse hyperbolic functions. Derivatives of inverse hyperbolic functions.

Module 2: Differentiation with applications to Chemistry-II

- Power series and their convergence. Results about the region of convergence of a power series(without proof). Radius of convergence. Functions defined by a power series. Results about term by term differentiation and integration of power series (without proof). Taylor's theorem with derivative form of remainder (without proof) and its use in approximating functions by polynomials. Taylor series and Maclaurin series and representation of functions by Taylor series. Taylor series of basic functions and the regions where these series converge to the respective functions. Binomial series as a Taylor series and its convergence. Obtaining Taylor series representation of other functions by differentiaion, integration, substitution etc.

- Functions of several variables. Graphs of functions of two variables. Equations of surfaces such as sphere, cylinder, cone, paraboloid, ellipsoid, hyperboloid etc. Partial derivatives and differentials. The chain rule (various forms). Euler's theorem for homogeneous functions. Jacobians.
  Exercise set 14.3; Questions 47 and 48.
  Exercise set 14.4; Question 50.
  Exercise set 14.5; Question 42.

- Local maxima and minima of functions of two variables. Use of partial derivatives in locating local maxima and minima. Lagrange method for finding maximum/minimum values of functions subject to one constraint.
  Exercise set 14.9; Question 20.

Module 3 : Linear Algebra

- The rows and columns of a matrix as elements of $\mathbb{R}^n$ for suitable n. Rank of a matrix as the maximum number of linearly independent rows/columns. Elementary row operations. Invariance of rank under elementary row operations. The echelon form and its uniqueness. Finding the rank of a matrix by reducing to echelon form.

- Homogeneous and non-homogeneous system of linear equations. Results about the existence and nature of solution of a system of equations in terms of the ranks of the matrices involved.

- The eigen value problem. Method of finding the eigen values and eigen vectors of a matrix. Basic properties of eigen values and eigen vectors. Eigen values and eigen vectors of a symmetric matrix.

- Diagonalisable matrices. Advantages of diagonalisable matrices in computing matrix powers and solving system of equations. The result(without proof) that a square matrix of order n is diagonalisabe (i) if and only if it has n linearly independent eigen vectors (ii) if it has n distinct eigen values. Method of diagonalising a matrix. Diagonalisation of real symmetric matrices. Similar matrices.

Text for Module 1 and 2 : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Text for Module 3 : Peter V. O' Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

Semester II

Mathematics-II
(Integration, Differential Equations and Analytic Geometry)

Code: MM 1231.2

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

Overview

The complementary course in the second semester continues the trend indicated in the first, namely, laying emphasis on applications of integral calculus and vectors to problems in Chemistry. Module 1 consists of various applications of integration techniques. It also covers multiple integrals. Modules 2 deals with differential equations while Module 3 covers analytic geometry.

Module 1: Applications of integration

- Integral curves, integration from the view point of differential equations, direction fields Exercise set 5.2; Questions 43 and 44.
- Rectilinear motion: finding position and velocity by integration. Uniformly accelerated motion. The free-fall model. Integrating rates of change. Displacement in rectilinear motion. Distance travelled in rectilinear motion. Analysing the velocity versus time curve. Average value of a continuous function. Average velocity revisited.
  Exercise set 5.7; Questions 3, 4, 5, 6, 29 and 55.
- Use of definite integrals in finding area under curves, area between two curves, volume of revolution, arc length and surface area of a solid of revolution.
- The idea of approximating the volume under a bounded surface in 3-space by volumes of boxes, leading to the definition of double integrals of functions of two variables over bounded regions. Evaluation of double integrals by iterated integrals. Evaluation by changing to polar co-ordinates and by suitably changing order of integration in the iterated integral. Applications to finding the volume of solids under bounded surfaces.

- Triple integrals over bounded regions in three space. Evaluation by iterated integrals. Cylindrical coordinates and spherical coordinates and their relation to Cartesian coordinates. Use of cylindrical and spherical co-ordinates in evaluating triple integrals. Applications of triple integrals to finding volumes of solid objects.

Module 2: Differential equations

- Review of basic concepts about differential equations and their solutions. Method of solving special types of first order ODEs such as variable separable, exact, homogeneous, and linear. Finding the family of curves orthogonal to a given family.
- Second order linear differential equations. Nature of the general solution of homogeneous and non-homogeneous linear ODEs. Extension to higher order ODE.
- Second order linear homogeneous ODEs with constant coefficients. The characteristic equation and its use in finding the general solution. Extension of the results to higher order ODEs.
- Second order linear non-homogeneous ODEs with constant coefficients. General solution as the sum of complementary function and particular integral. Second order linear differential operator and its properties. The inverse operator and its properties. Operator method for finding the particular integral of simple functions. Extension of the results to higher order equations. Cauchy and Legendre equations and their solutions by reducing to equations with constant coefficients by suitable change of variable.

Module 3: Analytic Geometry

- Geometric definition of a conic-the focus, directrix and eccentricity of a conic. Classification of conics into ellipse, parabola and hyperbola based on the value of eccentricity. Sketch of the graphs of conics. Reflection properties of conic sections.
  Exercise set 11.4; Questions 39 - 43.
- Equations of the conics in standard positions. Equations of the conics which are translated from standard positions vertically or horizontally. Parametric representation of conics in standard form. Condition for a given straight line to be a tangent to a conic. Equation of the tangent and normal to a conic at a point.
- Asymptotes of a hyperbola. Equation of the asymptotes.
- Conic sections in polar coordinates. Eccentricity of an ellipse as a measure of flatness. Polar equations of conics. Sketching conics in polar coordinates. Kepler's Laws.

  Example 4 of section 11.6.

Text for Module 1 and 3 : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Text for Module 2 : Kreyzig, *Advanced Engineering Mathematics*, 8^{th} edition,John Wiley.

Semester III

Mathematics-III
(Vector Analysis and Theory of Equations)

Code: MM 1331.12

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

Module 1: Vector Differentiation

- Vector function of a single variable and representation in terms of standard basis. Limit of a vector function and evaluation of limit in Cartesian representation. Continuous vector functions and the idea that such functions represent oriented space curves. Examples.
- Derivative of a vector function and its geometric significance. Derivative in terms of Cartesian components. Tangent vector to a curve, smooth and piecewise smooth curves. Applications to finding the length and curvature of space curves, velocity and acceleration of motion along a curve etc.
- Scalar field and level surfaces. The gradient vector of a scalar field (Cartesian form) at a point and its geometric significance. Gradient as an operator and its properties. Directional derivative of a scalar field and its significance. Use of gradient vector in computing directional derivative.
- Vector fields and their Cartesian representation. Sketching of simple vector fields in the plane. The curl and divergence of a vector field(Cartesian form) and their physical significance. The curl and divergence as operators, their properties. Irrotational and solenoidal vector fields. Various combinations of gradient, curl and divergence operators.

Module 2: Vector Integration

- The method of computing the work done by a force field in moving a particle along a curve leading to the definition of line integral of a vector field along a smooth curve. Scalar representation of line integral. Evaluation as a definite integral. Properties. Line integral over piecewise smooth curves. Green's theorem in the plane (without proof) for a region bounded by a simple closed piecewise smooth curve.
- Oriented surfaces. The idea of flux of a vetor field over a surface in 3-space. The surface integral of a vector field over a bounded oriented surface. Evaluation by reducing to a double integral. Use of cylindrical and spherical co-ordinates in computing surface integral over cylindrical and spherical surfaces.
- Stokes' theorem (without proof) for an open surface with boundary a piecwise smooth closed curve. Gauss' divergence theorem (without proof). Verification of the theorems in simple cases and their use in computing line integrals or surface integrals which are difficult to evaluate directly. Physical intrepretation of divergence and curl in terms of the velocity field of a fluid flow.

- Conservative fields and potential functions. Relation of conservative vector fields to their irrotational nature and the path- independence of line integrals in the field (without proof). Significance of these results in the case of conservative force fields such as gravitational, magnetic and electric fields. Method of finding the potential function of a conservative field.

Module 3: Theory of Equations

- Fundamental theorem of Algebra (without proof), relations between roots and coefficients of a polynomial, finding nature of roots of polynomials without solving-Des Cartes' rule of signs, finding approximate roots via bisection method, Newton-Raphson method

Text for Module 1 and 2 : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Text for Module 3 :
Barnard and Child, *Higher Algebra*, Macmillan

K A Stroud, *Advanced Engineering Mathematics*, 4^{th} edition,Palgrave, 2003.

Semester IV

Mathematics-IV
(Abstsract Algebra and Linear Transformations)

Code: MM 1431.2

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

Module 1: Abstract Algebra

- Groups–definition and examples, elementary properties, finite groups and subgroups, cyclic groups, elementary properties, groups of permutations

- Rings and Fields - definition and examples

  [Sections 2, 4, 5, 6, 8 (excluding the subsection on Cayley's theorem) and 18 (excluding the subsection on homomorphism and isomorphism) of text . Proofs of theorems are excluded. However ideas contained in theorems and definitions should be explained with illustrative examples and problems.]

  (See also J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications for examples of symmetry groups)]

Module 2: Linear Transformations

- Linear independence of vectors. Linear independence of Matrix columns.

- Linear transformations from $\mathbb{R}^n$ into $\mathbb{R}^m$. Matrix transformations. Linear transformation.
- The matrix of a Linear transformation. Matrix representation of simple tranformations such as rotation, reflection, projection etc. on the plane.

[Sections 1.7, 1.8, and 1.9 of text]

Text for Module 1: J B Fraleigh, *A First Course in Abstract Algebra*, Narosa Publications
Text for Module 2: David C. Lay, *Linear Algebra and its applications*, Third Edition Pearson

References

1. Thomas and Finney, Calculus and Analytic Geometry, Ninth Edition, Addison–Wesley.
2. Michael D. Greenberg, Advanced Engineering Mathematics, Pearson Education, 2002.
3. James Stewart, Essential Calculus, Thompson Publications, 2007.
4. David C. Lay, Linear Algebra, Thompson Publications, 2007.
5. George F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, 2003
6. T. Gamelin, Complex Analysis, Springer-verlag, 2006
7. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications
8. Brown and Churchil, Complex Variables and Applications, McGraw-Hill Higher Education; 8 edition, 2008
9. S L Loney, The elements of coordinate geometry
10. SAGE Math official website http://www.sagemath.org/
11. Gnuplot official website containing documentation and lot of examples http://www.gnuplot.info/
12. More help and examples on gnuplot http://people.duke.edu/ hpgavin/gnuplot.html
13. Maxima documentations http://maxima.sourceforge.net/documentation.html

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

Semester I
Mathematics-I
(Differentiation and Theory of Equations)

CODE: MM 1131.3 Instructional hours per week: 4
No. of Credits: 3 credits

Overview of the course:
The complementary course intended for Geology students lays emphsis on the application of mathematical methods to Geology. The two modules on Calculus links the topic to *the real world and the student's own experience* as the authors of the text put it. Doing as many of the indicated exercises from the text should prove valuable in understanding the applications of the theory. Applications to Geology on the lines of those in Physics as given in the text could be obtained from the net. The third module covers theory of equations.

Module 1: Differentiation with applications to Geology-I

- Functions and graphs of functions with examples from Geology. Interpretations of slope. The graph showing direct and inverse proportional variation. Mathematical models (functions as models). Parametric equations. Cycloid.
  Exercise set 1.8; Questions $31 - 34$.
- Instantaneous velocity and the slope of a curve. Limits. Infinite limits and vertical asymptotes. Limits at infinity and horizontal asymptotes. Some basic limits. Indeterminate forms of the type $0/0$.
  Exercise set 2.1; Questions 27 and 28.
- Continuity. Slopes and rates of change. Rates of change in applications. Derivative.
  Exercise set 3.1; Questions 1, 2 and 16.
- Techniques of differentiation. Higher derivatives. Implicit differentiation. Related rates.Local linear approximation. Differentials.
  Examples $1 - 6$.Exercise set 3.8; Questions $53 - 55$.
- Rectilinear motion. Speeding up and slowing down. Analysing the position versus time curve. Free fall motion.
  Examples $1 - 7$. Exercise set 4.4; Questions 8, 9, $30 - 32$.
- Absolute maxima and minima. Applied maximum anmd minimimum problems.
  Exercise set 4.6; Questions 47 and 48.
- Statement of Rolle's Theorem and Mean Value Theorem. The velocity interpretation of Mean Value Theorem. Statement of theorems $4.1.2$ and 4.83 (consequences of the Mean Value Theorem).

- Inverse functions. Continuity and differentiability of inverse functions. Graphing inverse functions. exponential and logarithmic functions. Derivatives of logarithmic functions and logarithmic differentiation. Derivatives of the exponential function.Graphs and applications involving logarithmic and exponential functions.
  Exercise set 7.4; Question 50.

- L'Hospital's Rule for finding the limits (without proof) of indeterminate forms of the type $0/0$ and ∞/∞. Analysing the growth of exponential functions using L'Hospital's Rule. Indeterminate forms of type$0 \cdot \infty$ and $\infty - \infty$ and their evaluation by converting them to $0/0$ or ∞/∞ types. Indeterminate forms of type 0^0, ∞^0 and 1^∞.

- Definitions of hyperbolic functions. Graphs of hyperbolic functions. Hyperbolic identities. Why they are called hyperbolic functions. Derivatives of hyperbolic functions. Inverse hyperbolic functions. Logarithmic forms of inverse hyperbolic functions. Derivatives of inverse hyperbolic functions.

Module 2: Differentiation with applications to Geology-II

- Power series and their convergence. Results about the region of convergence of a power series(without proof). Radius of convergence. Functions defined by a power series. Results about term by term differentiation and integration of power series (without proof). Taylor's theorem with derivative form of remainder (without proof) and its use in approximatingfunctions by polynomials. Taylor series and Maclaurin's series and representation of functions by Taylor series. Taylor series of basic functions and the regions where these series converge to the respective functions. Binomial series as a Taylor series and its convergence. Obtaining Taylor series representation of other functions by differentiaion, integration, substitution etc.

- Functions of two variables. Graphs of functions of two variables. Equations of surfaces such as sphere, cylinder, cone, paraboloid, ellipsoid, hyperboloid etc. Partial derivatives and chain rule (various forms). Euler's theorem for homogeneous functions. Jacobians. Exercise set 14.3; Questions 47 and 48.Exercise set 14.4; Question 50.Exercise set 14.5; Question 42.

- Local maxima and minima of functions of two variables. Use of partial derivatives in locating local maxima and minima. Lagrange method for finding maximum/minimum values of functions subject to one constraint.
  Exercise set 14.9; Question 20.

Module 3: Theory of equations

- Polynomial equations and fundamental theorem of algebra (without proof). Applications of the fundamental theorem to equations having one or more complex roots, rational roots or multiple roots.

- Relations between roots and coefficients of a polynomial equation and computation of symmetric functions ofroots. Finding equations whose roots are functions of the roots of a given equation. Reciprocal equation and method of finding its roots.

- Analytical methods for solving polynomial equations of order up to four-quadratic formula, Cardano's method for solving cubic equations), Ferrari's method (for quartic equations). Remarks about the insolvability of equations of degree five or more. Finding the nature of roots without solving-Des Cartes' rule of signs.

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

TEXTS:

1. Howard Anton, et al, *Calculus*. Seventh Edition, John Wiley
2. Barnard and Child, *Higher Algebra*, Macmillan.

REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. Peter V. O' Neil, *Advanced Engineering Mathematics*, ThompsonPublications, 2007

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

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

Semester II
Mathematics-II
(Integration, Differential Equations and Matrices)

CODE: MM 1231.3 — Instructional hours per week: 4
No. of Credits: 3

Overview of the course:
The complementary course in the second semester continues the trend indicated in the first, namely, laying emphasis on applications of integral calculus and vectors to problems in Geology. Module 1 consists of a review of basic integration techniques and the applications of integration. It also covers multiple integrals. Module 2 deals with differential equations, while Module 3 covers matrix theory.

Module 1: Integration (with applications to Geology)

- Indefinite integrals (Review only), integral curves, integration from the view point of differential equations, direction fields
  Exercise set 5.2; Questions 43 and 44
- (Review only) Definite integral and Fundamental Theorem of Calculus.
- Rectilinear motion: finding position and velocity by integration. Uniformly accelerated motion. The free-fall model. integrating rates of change. Displacement in rectilinear motion. Distance travelled in rectilinear motion. Analysing the velocity versus time curve. Average value of a continuous function. Average velocity revisited.
  Exercise set 5.7; Questions 3, 4, 5, 6, 29 and 55
- Review of integration techniques.
- Use of definite integrals in finding area under curves, area between two curves, volume of revolution, arc length and surface area of a solid of revolution.
- The idea of approximating the volume under a bounded surface in 3-space by volumes of boxes, leading to the definition of double integrals of functions of two variables over bounded regions. Evaluation of double integrals by iterated integrals. Evaluation by changing to polar co-ordinates and by suitably changing order of integration in the iterated integral. Applications to finding the volume of solids under bounded surfaces.
- Triple integrals over bounded regions in three space. Evaluation by iterated integrals. Cylindrical coordinates and spherical coordinates and their relation to Cartesian coordinates. Use of cylindrical and spherical co-ordinates in evaluating triple integrals. Applications of triple integrals to finding volumes of solid objects.

Module 2: Differential Equations

- Review of basic concepts about differential equations and their solutions. Method of solving special types of first order ODEs such as variable separable, exact, homogeneous, and linear. Finding the family of curves orthogonal to a given family.
- Second order linear differential equations. Nature of the general solution of homogeneous and non-homogeneous linear ODEs. Extension to higher order ODEs.
- Second order linear homogeneous ODEs with constant coefficients. The characteristic equation and its use in finding the general solution. Extension of the results to higher order ODEs.
- Second order linear non-homogeneous ODEs with constant coefficients. General solution as the sum of complementary function and particular integral. Second order linear differential operator and its properties. The inverse operator and its properties. Operator method for finding the particular integral of simple functions. Extension of the results to higher order equations. Cauchy and Legendre equations and their solutions by reducing to equations with constant coefficients by suitable change of variable.

Module 3: Theory of Matrices

- (Review only) basic concepts about matrices. Operations involving matrices, different types of matrices. Representation of a system of linear equation in matrix form. Inverse of a matrix, Cramer's rule.
- The rows and columns of a matrix as elements of $\mathbb{R}^n$ for suitable n. Rank of a matrix as the maximum number of linearly independent rows/columns. Elementary row operations. Invariance of rank under elementary row operations. The Echelon form and its uniqueness. Finding the rank of a matrix by reducing to echelon form.
- Homogeneous and non-homogeneous system of linear equations. Results about the existence and nature of solution of a system of equations in terms of the ranks of the matrices involved.
- The eigen value problem. Method of finding the eigen values and eigen vectors of a matrix. Basic properties of eigen values and eigen vectors. Eigen values and eigen vectors of a symmetric matrix.
- Diagonalisable matrices. Advantages of diagonalisable matrices in computing matrix powers and solving system of equations. The result that a square matrix of order n is diagonalisabe (i) if and only if it has n linearly independent eigen vectors (ii) if it has n distinct eigen values. Method of diagonalising a matrix. Diagonalisation of real symmetric matrices. Similar matrices.

Text for Module 1: Howard Anton, et al, *Calculus*. Seventh Edition, John Wiley
Text for Module 2: Kreyzig, *Advanced Engineering Mathematics*, 8^{th} edition, John Wiley.
Text for Module 3: David C. Lay, *Linear Algebra*, Thompson Publications, 2007.

References:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. Peter V. O' Neil, *Advanced Engineering Mathematics*, ThompsonPublications, 2007
4. Michael D. Greenberg, *Advanced Engineering Mathematics*, PearsonEducation, 2002.
5. George F Simmons, *Differential equations with applications and historical notes*, Tata McGraw Hill, 2003

Distribution of instructional hours:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

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

Semester III
Mathematics-III
(Analytic Geometry, Complex Numbers, Abstract Algebra)

CODE: MM 1331.3 — Instructional hours per week: 5
No. of Credits: 4

Module 1: Analytic Geometry

- Geometric definition of a conic-the focus, directrix and eccentricity of a conic. Classification of conics into ellise, parabola and hyperbola based on the value of eccentricity. Sketch of the graphs of conics. Reflection properties of conic sections.
  Exercise set 11.4; Questions $39 - 43$.

- Equations of the conics in standard positions. Equations of the conics which are translated from standard positions vertically or horizontally. Parametric representation of conics in standard form. Condition for a given straight line to be a tangent to a conic. Equation of the tangent and normal to a conic at a point.

- Asymptotes of a hyperbola. Equation of the asymptotes. Rectangular hyperbola and its parameric representation. Equation of tangent and normal to a rectangular hyperbola at a given point.

- Rotation of co-ordinate axes. Equation connecting the co-ordinates in the original and rotated axes. Elimination of the cross product term in a general second degree equation by suitable rotation. Identifying conics in non-standard positions represented by general second degree equation by suitable rotation of axes. The discriminant of a general second degree equationand its invariance under rotation of co-ordinate axes. The conditions on the discriminant for the general second degree equation to represent a conic, a pair of straight lines or a circle.

- Conic sections in polar coordinates. Eccentricity of an ellipse as a measure of flatness. Polar equations of conics. Sketching conics in polar coordinates. Kepler's Laws.
  Example 4 of section 11.6.

Module 2: Complex Numbers

- Review of basic results: Introduction to complex numbers, representation of complex numbers, the Argand diagram, De Moivre's theorem, evaluation of roots of complex numbers, finding n^{th} roots of unity, its properties,

- Expansion of trigonometric functions of multiples of angles, expansion of powers of trigonometric functions, separation into real and imaginary parts, Summation of series.

Module 3: Abstract algebra

- Groups–definition and examples, elementary properties, finite groups and subgroups, cyclic groups, elementary properties, symmetry of plane figures.
- Rings and fields–definition and examples,
- Vector spaces, definition and examples, elementary properties, linear dependence and independence, basis and dimension.

Text for Modules 1: Howard Anton, et al, *Calculus*. Seventh Edition, John Wiley
Text for Module 2: S K Mapa, *Higher Algebra (Classical)*, Sarat Book Distributors, Kolkata.
Text for Module 3: J B Fraleigh, *A First Course in Abstract Algebra*, Narosa Publications
References:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. D A R Wallace, *Groups, Rings and Fields*, Springer

Distribution of instructional hours:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

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

Semester IV
Mathematics-IV
(Vector Analysis and Fourier Series)

CODE: MM 1431 — Instructional hours per week: 5
No. of Credits: 4

Module 1: Vector Differentiation

- (Review only) Vectors in 3-space. Addition of two vectors, multiplication of a vector by a scalar and basic properties of theseoperations. Representation in Cartesian coordinates using standard basis. Dot, cross and triple product of vectors, their significance and properties.
- Vector function of a single variable and representation in terms of standard basis. Limit of a vector function and evaluation of limit in Cartesian representation. Continuous vector functions and the idea that such functions represent oriented space curves. Examples.
- Derivative of a vector function and its geometric significance. Derivative in terms of Cartesian components. Tangent vector to a curve, smooth and piecewise smooth curves. Applications to finding the length and curvature of space curves, velocity and acceleration of motion along a curve etc.
- Scalar field and level surfaces. The gradient vector of a scalar field (Cartesian form) at a point and its geometric significance. Gradient as an operator and its properties. Directional derivative of a scalar field and its significance. Use of gradient vector in computing directional derivative.
- Vector fields and their Cartesian representation. Sketching of simple vector fields in the plane. The curl and divergence of a vector field(Cartesian form) and their physical significance. The curl and divergence as operators, their properties. Irrotational and solenoidal vector fields. Various combinations of gradient, curl and divergence operators.

Module 2: Vector Integration

- The method of computing the work done by a force field in moving a particle along a curve leading to the definition of line integral of a vector field along a smooth curve. Scalar representation of line integral. Evaluation as a definite integral. Properties. Line integral over piecewise smooth curves. Green's theorem in the plane (without proof) for a region boundedby a simple closed piecewise smooth curve.
- Oriented surfaces. The idea of flux of a vetor field over a surface in3-space. The surface integral of a vector field over a bounded oriented surface. Evaluation by reducing to a double integral. Use of cylindrical and spherical co-ordinates in computing surface integral over cylindrical and spherical surfaces.

- Stokes' theorem (without proof) for an open surface with boundary a piecwise smooth closed curve. Gauss' divergence theorem(without proof). Verification of the theorems in simple cases and their use in computing line integrals or surface integrals which are difficult to evaluate directly. Physical intrepretation of divergence and curl in terms of the velocity field of a fluid flow.

- Conservative fields and potential functions. Relation of conservative vector fields to their irrotational nature and the path- independence of line integrals in the field (without proof). Significance of these results in the case of conservative force fields such as gravitational, magnetic and electric fields. Method of finding the potential function of a conservative field.

Module 3: Fourier Series and transforms

- Periodic functions, trigonometric series, Fourier series, evaluation of Fourier coefficients for functionsdefined in $(-\infty, +\infty)$, Fourier series for odd and even functions, half range series, Fourier series for odd and even functions, Fourier series of functions defined in $(-L, +L)$.

- Fourier integrals and Fourier transforms.

Text for Modules 1 and 2: Howard Anton, et al, *Calculus*. Seventh Edition, John Wiley
Text for Module 3: Kreyzig, *Advanced Engineering Mathematics*, 8^{th} edition, John Wiley. Chapter 8, Sections 1, 2, 3, 4, 8, 10.

REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.

2. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.

3. Peter V. O' Neil, *Advanced Engineering Mathematics*, ThompsonPublications, 2007

4. Michael D. Greenberg, *Advanced Engineering Mathematics*, PearsonEducation, 2002.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

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

Semester I
Mathematics-I
(Theory of equations, Infinite Series and Analytic Geometry)

CODE: MM 1131.4 Instructional hours per week: 4
No. of Credits: 3

Overview of the course:

The complementary course intended for Statistics students lays emphsis on the application of mathematical methods to Statistics. The First Module develops concepts in the theory of equations and covers the methods of solving the cubic and the quartic. The second module starts with a sequence of real numbers and goes on to discuss various tests for the convergence of an infinite series. The third Module treats analytic geometry.

Module 1: Theory of equations

- Polynomial equations and fundamental theorem of algebra (without proof). Applications of the fundamental theorem to equations having one or more complex roots, rational roots or multiple roots.
- Relations between roots and coefficients of a polynomial equation and computation of symmetric functions of roots. Finding equations whose roots are functions of the roots of a given equation. Reciprocal equation and method of finding its roots.
- Analytical methods for solving polynomial equations of order up to four-quadratic formula, Cardano's method for solving cubic equations, Ferrari's method (for quartic equations). Remarks about the insolvability of equations of degree five or more. Finding the nature of roots without solving-Des Cartes' rule of signs.

Module 2: Infinite Series

- Sequences of real numbers and limit of a sequence. Convergent and divergent sequences. Algebra of convergent sequences.Bounded and monotone sequences. The result that bounded monotone sequences are convergent (without proof). Infinite limits and limit at infinity with examples.
- Infinite series as a sequence of partial sums of a given sequence. Convergence and divergence of series. The behaviour of the series $\sum 1/n^p$. Tests of convergence–comparison test, ratio test and root test. Examples illustrating the use of these tests. Series of positive and negative terms. Absolute convergence. The result that absolute convergence impliesconvergence. Tests for absolute convergence-comparison, ratio and root tests. Alternating series and Leibnitz test for convergence.

Module 3: Analytic geometry

- (Review) Geometric definition of a conic-the focus, directrix and eccentricity of a conic. Classification of conics into ellise, parabola and hyperbola based on the value of eccentricity. Sketch of the graphs of conics.
- Equations of the conics in standard positions. Equations of the conics which are translated from standard positions vertically or horizontally. Parametric representation of conics in standard form. Condition for a given straight line to be a tangent to a conic. Equation of the tangent and normal to a conic at a point.
- Asymptotes of a hyperbola. Equation of the asymptotes. Rectangular hyperbola and its parameric representation. Equation of tangent and normal to a rectangular hyperbola at a given point.
- Rotation of co-ordinate axes. Equation connecting the co-ordinates in the original and rotated axes. Elimination of the cross product term in a general second degree equation by suitable rotation. Identifying conics in non-standard positions represented by general second degree equation by suitable rotation of axes. The discriminant of a general second degree equation and its invariance under rotation of co-ordinate axes. The conditions on the discriminant for the general second degree equation to represent a conic, a pair of straightlines or a circle.

Texts for Modules 1 and 2:

1. Barnard and Child, *Higher Algebra*, Macmillan.
2. S K Mapa, *Higher Algebra (Classical)*, Sarat Book Distributors, Kolkata.

Texts for Module 3:
Howard Anton, et al, *Calculus*. Seventh Edition, John Wiley
REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. Peter V. O' Neil, *Advanced Engineering Mathematics*, ThompsonPublications, 2007

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

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

Semester II
Mathematics-II
(Differential Calculus)

CODE: MM 1231.4 Instructional hours per week: 4
No. of Credits: 3

Overview of the course:
The complementary course intended for Statistics students lays emphsis on the application of mathematical methods to Statistics. The two modules on Differential Calculus links the topic to *the real world and the student's own experience* as the authors of the text put it. Doing as many of the indicated exercises from the text should prove valuable in understanding the applications of the theory. Applications to Statistics on the lines of those in Physics as given in the text could be obtained from the net. The third Module on Integral Calculus reviews basic integration techniques and covers several applications of integration. I t also treats multiple integrals. The emphasis should be on applications to statistical problems.

Module 1: Differentiation with applications to Statistics-I

- Functions and graphs of functions with examples from Statistics. Interpretations of slope. The graph showing direct and inverse proportional variation. Mathematical models (functions as models). Parametric equations. Cycloid.
  Exercise set 1.8; Questions $31 - 34$.
- Instantaneous velocity and the slope of a curve. Limits. Infinite limits and vertical asymptotes. Limits at infinity and horizontal asymptotes. Some basic limits. Indeterminate forms of the type $0/0$.
  Exercise set 2.1; Questions 27 and 28.
- Continuity. Slopes and rates of change. Rates of change in applications. Derivative.
  Exercise set 3.1; Questions 1, 2 and 16.
- Techniques of differentiation. Higher derivatives. Implicit differentiation. Related rates.Local linear approximation. Differentials.
  Examples $1 - 6$.Exercise set 3.8; Questions $53 - 55$.
- Rectilinear motion. Speeding up and slowing down. Analysing the position versus time curve. Free fall motion.
  Examples $1 - 7$. Exercise set 4.4; Questions 8, 9, $30 - 32$.
- Absolute maxima and minima. Applied maximum anmd minimimum problems.
  Exercise set 4.6; Questions 47 and 48.
- Statement of Rolle's Theorem and Mean Value Theorem. The velocity interpretation of Mean Value Theorem. Statement of theorems 4.1.2 and 4.83 (consequences of the Mean Value Theorem).

- Inverse functions. Continuity and differentiability of inverse functions. Graphing inverse functions. exponential and logarithmic functions. Derivatives of logarithmic functions and logarithmic differentiation. Derivatives of the exponential function. Graphs and applications involving logarithmic and exponential functions.
  Exercise set 7.4; Question 50.

- L'Hospital's Rule for finding the limits (without proof) of indeterminate forms of the type $0/0$ and ∞/∞. Analysing the growth of exponential functions using L'Hospital's Rule. Indeterminate forms of type$0 \cdot \infty$ and $\infty - \infty$ and their evaluation by converting them to $0/0$ or ∞/∞ types. Indeterminate forms of type 0^0, ∞^0 and 1^∞.

- Definitions of hyperbolic functions. Graphs of hyperbolic functions. Hyperbolic identities. Why they are called hyperbolic functions. Derivatives of hyperbolic functions. Inverse hyperbolic functions. Logarithmic forms of inverse hyperbolic functions. Derivatives of inverse hyperbolic functions.

Module 2: Differentiation with applications to Statistics-II

Power series and their convergence. Results about the region of convergence of a power series(without proof). Radius of convergence. Functions defined by a power series. Results about term by term differentiation and integration of power series (without proof). Taylor's theorem with derivative form of remainder (without proof) and its use in approximatingfunctions by polynomials. Taylor series and Maclaurin's series and representation of functions by Taylor series. Taylor series of basic functions and the regions where these series converge to the respective functions. Binomial series as a Taylor series and its convergence. Obtaining Taylor series representation of other functions by differentiaion, integration, substitution etc.

Module 3: Differentiation with applications to Statistics-III

- Functions of two variables. Graphs of functions of two variables. Equations of surfaces such as sphere, cylinder, cone, paraboloid, ellipsoid, hyperboloid etc. Partial derivatives and chain rule (various forms). Euler's theorem for homogeneous functions. Jacobians.
  Exercise set 14.3; Questions 47 and 48.Exercise set 14.4; Question 50.Exercise set 14.5; Question 42.

- Local maxima and minima of functions of two variables. Use of partial derivatives in locating local maxima and minima. Lagrange method for finding maximum/minimum values of functions subject to one constraint.
  Exercise set 14.9; Question 20.

TEXT: Howard Anton, et al, *Calculus*. Seventh Edition, John Wiley
REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. Peter V. O' Neil, *Advanced Engineering Mathematics*, ThompsonPublications, 2007
4. Michael D. Greenberg, *Advanced Engineering Mathematics*, PearsonEducation, 2002.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

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

Semester III
Mathematics-III
(Integration and Complex Numbers)

CODE: MM 1331.4

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

Module 1: Integration with applications to Statistics-I

- Indefinite integrals (Review only), integral curves, integration from the view point of differential equations, direction fields
  Exercise set 5.2; Questions 43 and 44
- (Review only) Definite integral and the Fundamental Theorem of Calculus.
- Techniques of integration.
- Rectilinear motion: finding position and velocity by integration. Uniformly accelerated motion. The free-fall model. integrating rates of change. Displacement in rectilinear motion. Distance travelled in rectilinear motion. Analysing the velocity versus time curve. Average value of a continuous function. Average velocity revisited.Exercise set 5.7; Questions 3, 4, 5, 6, 29 and 55
- Use of definite integrals in finding area under curves, area between two curves, volume of revolution, arc length and surface area of a solid of revolution.

Module 2: Integration with applications to Statistics-II

- The idea of approximating the volume under a bounded surface in 3-space by volumes of boxes, leading to the definition of double integrals of functions of two variables over bounded regions. Evaluation of double integrals by iterated integrals. Evaluation by changing to polar co-ordinates and by suitably changing order of integration in the iterated integral. Applications to finding the volume of solids under bounded surfaces.
- Triple integrals over bounded regions in 3-space. Evaluation by iterated integrals. Cylindrical coordinates and spherical coordinates and their relation to Cartesian coordinates. Use of cylindrical and spherical co-ordinates in evaluating triple integrals. Applications of triple integrals to finding volumes of solid objects.

Module 3: Complex Numbers

- Review of basic results: Introduction to complex numbers, representation of complex numbers, the Argand diagram, De Moivre's theorem, evaluation of roots of complex numbers, finding n^{th} roots of unity, its properties,
- Expansion of trigonometric functions of multiples of angles, expansion of powers of trigonometric functions, separation into real and imaginary parts, Summation of series.

Text for Modules 1 and 2 : Howard Anton, et al, *Calculus*. Seventh Edition, John Wiley
Text for Module 3: S K Mapa, *Higher Algebra (Classical)*, Sarat Book Distributors, Kolkata.
REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 35 hours; Module 2: 35 hours; Module 3: 20 hours

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

Semester IV
Mathematics-IV
(Linear Algebra)

CODE: MM 1431.4 — Instructional hours per week: 5
No. of Credits: 4

Module 1: Vector Spaces over $\mathbb{R}$

- Vector in 3-space as an ordered triple of real numbers. Addition of two vectors and multiplication of a vector by a scalar. Algebra of vectors involving addition and scalar multiplication. The norm of a vector. The dotproduct and orthogonal vectors. Geometric interpretation of these concepts andtheir connection to the traditional method of representing a vector in terms ofstandard unit vectors.
- The $n-$tuple as a generalisation of ordered triple and the space $\mathbb{R}^n$of all $n-$tuples. Addition of two $n-$tuples and multiplication ofan $n-$tuple by a scalar. Listing of the algebraic properties of $\mathbb{R}^n$ thatmakes it a vector space. Dot product of $n-$tuples and orthogonality. TheCauchy-Schwarz inequality in $\mathbb{R}^n$.
- Sub space of $\mathbb{R}^n$. Geometric meaning of subspaces in $\mathbb{R}^2$.and $\mathbb{R}^3$. Linear dependence and independence of vectors in $\mathbb{R}^n$. Basis anddimension and the standard basis of $\mathbb{R}^n$. Orthogonal and orthonormal bases.Representation of an arbitrary vector in an orthonormal basis. The Gram-Schmidtorthogonalisation process.

Module 2: Theory of Matrices

- (Review only) basic concepts about matrices. Operations involving matrices,different types of matrices. Representation of a system of linear equation inmatrix form. Inverse of a matrix, Cramer's rule.
- The rows and columns of a matrix as elements of $\mathbb{R}^n$ for suitable n. Rank of a matrix as the maximum number of linearly independent rows/columns. Elementary row operations. Invariance of rank under elementary row operations. The Echelon form and its uniqueness. Finding the rank of a matrix by reducing to echelon form.
- Homogeneous and non-homogeneous system of linear equations. Resultsabout the existence and nature of solution of a system of equations in terms ofthe ranks of the matrices involved.
- The eigen value problem. Method of finding the eigen values and eigenvectors of a matrix. Basic properties of eigen values and eigen vectors. Eigen values and eigen vectors of a symmetric matrix. The result that theeigen vectors of a real symmetric matrix form an orthogonal basis of $\mathbb{R}^n$.

- Diagonalisable matrices. Advantages of diagonalisable matrices incomputing matrix powers and solving system of equations. The result that asquare matrix of order n is diagonalisabe (i) if and only if it has $n$linearly independent eigen vectors (ii) if it has n distinct eigen values. Method of diagonalising a matrix. Diagonalisation of real symmetric matrices.

- Quadratic forms in $\mathbb{R}^n$ and matrix of quadratic forms. Canonical formof a quadratic form and the principal axes theorem. Geometric meaning ofprinciple axes theorem for quadratic forms in $\mathbb{R}^2$. Use of these results inidentifying the type of a conic that a general second degree equation mayrepresent.

Module 3: Linear Transformations

- Linear transformations from $\mathbb{R}^n$ into $\mathbb{R}^m$. Matrix of alinear transformation relative to a given pair of bases and lineartransformation defined by a matrix. Characterisation of linear transformationsfrom $\mathbb{R}^n$ into $\mathbb{R}^m$.

- Linear transformations from $\mathbb{R}^n$ into $\mathbb{R}^n$ and matix of suchtranformations. Matrix representation of simple tranformations such asrotation, reflection, projection etc. on the plane. Relation between matricesof a given transformation relative to two different bases. Method of choosing a suitable basis in which the matrix of a given transformation has the particularly simple form of a diagonal matrix.

Text: David C. Lay, *Linear Algebra*, Thompson Publications, 2007References:

1. T S Blyth and E F Robertson: *Linear Algebra*, Springer, Second Ed.

2. Peter V. O' Neil: *Advanced Engineering Mathematics*, ThompsonPublications, 2007

3. Michael D. Greenberg: *Advanced Engineering Mathematics*, PearsonEducation, 2002.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

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

Semester I
Mathematics for Economics-I

CODE: MM 1131.5

Instructional hours per week: 3
No. of Credits: 2

Overview of the course:
The complementary course intended for Economics students lays emphsis on the increased use of mathematical methods in Economics. The first Module of the first semester course discusses the basic concepts of functions, limits and continuity, which is essential to understand what is to follow in subsequent Modules. The second Module is on Differentiation. Applications to Economics abound in this area. The concepts should therefore be carefully motivated with suitable examples.

Module 1: Functions, Limits and Continuity

- Functions: Definition and examples of functions, domain and range of a function, graph of a function, notion of implicit and explicit functions, demand functions and curves, total revenue functions and curves, cost functions and curves, indifference function, indifference curves for flow of income over time.
- Limits and continuity of functions:Notion of the limit of a function with sufficient examples, algebra of limits (No proof), theorems on limits :$\lim_{x\to a} \dfrac{x^n - a^n}{x - a} = nx^{n-1}$, $\lim_{x\to 0} \dfrac{\sin x}{x} = 1$,$\lim_{x\to 0} \dfrac{e^x - 1}{x} = 1$, $\lim_{x\to 0} \dfrac{a^x - 1}{x} = \log a$, for $a > 0$(No proof), definition and examples of continuous functions, discontinuity, examples, geometrical meaning of continuity

Module 2: Differentiation-I

- Differentiation: Differentiation of functions of one variable, derivative as a rate measure, rules of differentiation, derivative of a function at a point, product rule, quotient rule, function of a function rule, derivatives of standard functions, derivatives and approximate values, geometrical interpretation of the derivative, applications in economics (such as marginal revenue, marginal cost),

REFERENCES:

1. R G D Allen, *Mathematical Analysis for Economics*, AITBS Publishers, D-2/15. Krishnan Nagar, New Delhi

2. Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

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

Semester II
Mathematics for Economics-II

CODE: MM 1231.5 | Instructional hours per week: 3

No. of Credits: 3

Overview of the course:
The first module on differentiation discusses differntials, increasing and decreasing functions and maxima and minima, along with several applications. The second module is on partial differentiation. It considers the maxima and minima of functions of two varibles and these are readily applied to problems in Economics.

Module 1: Differentiation-II

- Further differentiation:Successive derivatives of elementary functions, differentials and approximations, increasing and decreasing functions, turning points, points of inflexion, convexity of curves, maxima and minima of functions of one variable, the problem of average and marginal values,problems of monopoly and duopoly in economic theory.

Module 2: Partial Differentiation

- Partial Differentiation: Functions of several variables, Definition and examples partial differentiation of functions of two variables, maxima and minima of functions of many variables, Lagrangian multiplier method of maxima and minima of functions, illustrations from economics, geometrical interpretation of partial derivatives, total differentials, derivatives of implicit functions, higher order partial derivatives, homogeneous functions, applications(maxima and minima problems) in economics,

REFERENCES:

1. R G D Allen, *Mathematical Analysis for Economics*, AITBS Publishers, D-2/15. Krishnan Nagar, New Delhi

2. Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

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

Semester III
Mathematics for Economics-III

CODE: MM 1331.5 — Instructional hours per week: 3
No. of Credits: 3

Overview of the course:

The course follows the trends set in the first two semester. Integration techniques, definite integrals and approximate integration are discussed in the first module, highlighting applications to Economics. Various infinite series form the content of the second module.

Module 1: Integration

- Integration : Integral as an antiderivative, integration by substitution, integration by parts, definition of the definite integral, definite integrals and approximate integration (Simpson's rule and trapezoidal rule),total cost, marginal cost, capitalisation of an income flow, law of growth, Domar's models on public debt and national income.

Module 2: Series

- Series: geometric, binomial, exponential and logarithmic series, Taylor's formula, Taylor series, extension to many variables.

REFERENCES:

1. R G D Allen, *Mathematical Analysis for Economics*, AITBS Publishers, D-2/15. Krishnan Nagar, New Delhi

2. Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours