VIVEKANANDA COLLEGE
OF ARTS, SCIENCE & COMMERCE
(AUTONOMOUS)
ವಿವೇಕಾನಂದ ಕಲಾ, ವಿಜ್ಞಾನ
ಮತ್ತು ವಾಣಿಜ್ಯ ಮಹಾವಿದ್ಯಾಲಯ
(ಸ್ವಾಯತ್ತ)
(A unit of Vivekananda Vidyavardhaka Sangha Puttur ®)
(Re-accredited at 'A' Grade by NAAC) | Recognised as College with Potential for Excellence(CPE) by the UGC, New Delhi

No : VCP/AC/MSC/2022-23

Date : 30-11-2022

NOTIFICATION

Sub : Approved Syllabus of I and II Sem M.Sc Mathematics for PG Programme under Choice Based Credit System – reg.

Ref : Decision of the Academic Council at its meeting held on 26-11-2022 vide Agenda No : 3 (2022-23)

Pursuant to the above, the Syllabus of I and II Sem M.Sc Mathematics for PG Programme under Choice Based Credit System which was approved by the Academic Council at its meeting held on 26-11-2022 is hereby notified for implementation with effect from the academic year 2022-23 (MSCM 2022/101, MSCM 2022/201)

VIVEKANANDA COLLEGE OF ARTS, SCIENCE & COMMERCE (AUTONOMOUS) NEHRU NAGARA PUTTUR, D. K. 574 203

Principal / President
Academic Council

To:
1) The Chairman/Dean/HOD
2) Controller of Examination
3) Office Copy

VIVEKANANDA COLLEGE OF ARTS, SCIENCE & COMMERCE (AUTONOMOUS)
PUTTUR- 574203, D.K. KARNATAKA

SYLABI FOR
POST GRADUATE PROGRAM (PG)
M.SC. CURRICULUM FRAME WORK
CHOICE BASED CREDIT SYSTEM

M.SC. MATHEMATICS COURSE STRUCTURE

I & II SEMESTERS
TO BE IMPLEMENTED FROM THE ACADEMIC YEAR 2022-23

DEPARTMENT OF P G STUDIES IN MATHEMATICS (M.SC.)
CENTRE FOR POST GRADUATE STUDIES AND RESEARCH
VIVEKANANDA COLLEGE OF ARTS, SCIENCE & COMMERCE (AUTONOMOUS)
PUTTUR- 574203, D.K. KARNATAKA

VIVEKANANDA COLLEGE OF ARTS, SCIENCE & COMMERCE (AUTONOMOUS)
PUTTUR- 574203, D.K. KARNATAKA

SYLLABI
FOR THE YEAR 2022-23 AND ONWARDS

FRAMED UNDER CBCS

DEPARTMENT OF P G STUDIES IN MATHEMATICS (M.SC.)

I & II SEMESTERS

COURSE PATTERN AND SCHEME OF EXAMINATION
PG COURSE(M.SC.)

PRATHEEK RAI N
CHAIRPERSON
DEPARTMENT OF P G STUDIES IN MATHEMATICS (M.SC.)
CENTRE FOR POST GRADUATE STUDIES AND RESEARCH
VIVEKANANDA COLLEGE OF ARTS, SCIENCE & COMMERCE (AUTONOMOUS)
PUTTUR- 574203, D.K. KARNATAKA

Preamble:

M.Sc. (Master of Science) Mathematics is a Postgraduate Programme, that has a duration of 2yearswhich is divided into 4 semesters. The main aim of the Programme is intended to provide in-depth knowledge to the students in advanced Pure and Applied mathematics and prepare them for various research activities and career opportunities. The Programme is designed to impart proficiency inMathematical application in day-to-day in simple and complex situations. The Programme also will enable the learners to shine as collaborators and innovators in addressing social, technical, and business challenges. Programme through its wide range of Courses trains the students as competent citizens with advanced mathematical knowledge and ethically sound humans with its insistence of human ethics. The Programme is intended to promote the culture of interdisciplinary studies and research that is much needed for the current scenario.

Programme Outcome:

- Provide a strong foundation in different areas of Mathematics, so that the students can competewith their contemporaries and excel in the various careers in Mathematics.
- Develop abstract mathematical thinking.
- Motivate and prepare the students to pursue higher studies and research, thus contributing to the ever-increasing academic demands of the country.
- Enrich the students with strong communication and interpersonal skills, broad knowledge and an understanding of multicultural and global perspectives, to work effectively in multidisciplinary teams, both as leaders and team members.
- Facilitate integral development of the personality of the student to deal with ethical and professional issues, and also to develop ability for independent and lifelong learning.

Programme Specific Outcome:

- Students will demonstrate in-depth knowledge of Mathematics, both in theory and application.They develop problem-solving skills and apply them independently to problems in pure and applied mathematics.
- Students will attain the ability to identify, formulate and solve challenging problems in Mathematics. They assimilate complex mathematical ideas and arguments.
- Students will be able to analyse complex problems in Mathematics and propose solutions using research-based knowledge
- Students will be able to work individually or as a team member or leader in uniform and multidisciplinary settings.
- Students will develop confidence for self-education and ability for lifelong learning. Adjust themselves completely to the demands of the growing field of Mathematics by lifelong learning.
- Effectively communicate about their field of expertise on their activities, with their peer and society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations.
- Crack lectureship and fellowship exams approved by UGC like CSIR – NET and SET.

Consolidated List of Courses offered:

First Semester

Hard Core Courses:
1. PGMTH 101 Algebra - I
2. PGMTH 102 Linear Algebra- I
3. PGMTH 103 Real Analysis – I

Soft Core Courses:

4. PGMTS 104 Numerical Analysis
5. PGMTS 105 Number Theory

Lab (Soft core):

6. PGMTL 106 Lab - 1

Second Semester

Hard Core Courses:
1. PGMTH 202 Algebra – II
2. PGMTH 203 Real Analysis – II
3. VGMTH 204 Topology

Soft Core Courses:

4. PGMTS 205 Linear Algebra – II
5. PGMTS 206 Ordinary Differential Equations

Lab (Soft core):

6. PGMTL 207 Lab – 2

Open Elective (Hard Core):
1. PGMTE 201 Discrete Mathematics and Applications

The following shall be the Courses of study in the four semesters M.Sc. Mathematics Programme(CBCS-PG) from the academic year 2022-23

First Semester

Course Code	Course	Hard Core/ Soft Core/ Open Elective	Credits
PGMTH 101	Algebra - I	HC	4
PGMTH 102	Linear Algebra - I	HC	4
PGMTH 103	Real Analysis -I	HC	4
PGMTS 104	Numerical Analysis	SC	4
PGMTS 105	Theory of Combinatorics	SC	4
PGMTL 106	Lab - 1	SC	2

Second Semester

In this semester, the course 'MTE 451' is an "Open Elective Course" which is offered only to students of other departments. The other six courses are offered to the students of the department.

Course Code	Course	Hard Core/ Soft Core/ Open Elective	Credits
PGMTH 201	Algebra - II	HC	4
PGMTH 202	Real Analysis - II	HC	4
PGMTH 203	Topology	HC	4
PGMTS 204	Linear Algebra - II	SC	4
PGMTS 205	Ordinary Differential Equations	SC	4
PGMTL 206	Lab - 2	SC	2
PGMTOE 207	Discrete Mathematics and Applications	OE	3

A. Scheme of Instruction and Examination

First Semester

CourseCode	Instruction hours per week	Credits	Duration of Examination in hours	Semester Examination Max. Marks	Internal Assessment Max. Marks	Total Marks
PGMTH 101	4	4	3	70	30	100
PGMTH 102	4	4	3	70	30	100
PGMTH 103	4	4	3	70	30	100
PGMTS 104	4	4	3	70	30	100
PGMTS 105	4	4	3	70	30	100
PGMTL 106	2	2	3	35	15	50

Second Semester

CourseCode	Instruction hours per week	Credits	Duration of Examination in hours	Semester Examination Max. Marks	Internal Assessment Max. Marks	Total Marks
PGMTH 201	4	4	3	70	30	100
PGMTH 202	4	4	3	70	30	100
PGMTH 203	4	4	3	70	30	100
PGMTS 204	4	4	3	70	30	100
PGMTS 205	4	4	3	70	30	100
PGMTL 206	2	2	3	35	15	50
PGMTOE 207	3	3	3	70	30	100

Tutorials: There shall be at least 3 hours of tutorials per week for each course having 4 credits.

Scheme of Evaluation for Internal Assessment Marks:

1. **Theory Course:**
   Each Theory Course shall carry 30 marks for internal assessment based on two tests of 90minutes duration each.
2. **Lab:**
   Each Lab shall carry 15 marks for internal assessment based on two lab tests of 90 minutesduration each.

Pattern of Semester Examination:

1. **Theory Paper:**
   Each question paper for the theory course shall contain EIGHT questions out of which FIVE are to be answered. All questions carry equal marks.
2. **Lab Exam:**
   Each Lab exam question paper shall contain TWO questions on lab programmes which are to beexecuted.

B. Syllabi of Each Semester
I Semester

PGMTH 101	Algebra- I	4 Credits (48 hours)

Course Outcome: To introduce the concepts and to develop working knowledge on fundamentals of algebra. Students will have the knowledge and skills to apply the concepts of the course in pattern recognition in the field of computer science and also for diverse situations in physics, chemistry and other streams. This course is a foundation for next course in Algebra.

Course Specific Outcome: At the end of the course students will have the knowledge and skills tounderstand, explain in depth and apply the fundamental concepts-

- Groups
- Structure of Groups
- Rigid motions, isometries
- Rings and integral domains.

Unit I - Groups and Subgroups: (12 Hours)

Binary operations, Isomorphic binary operations, Groups, Subgroups, Cyclic groups, Generating sets and Cayley digraphs, Groups of permutations, Orbits, Cycles and alternating groups, Cosets and Lagrange's theorem.

Unit II - Product Groups, Homomorphism and Quotient Groups: (12 Hours)

Direct products and finitely generated abelian groups, Homomorphisms, Factor groups, Factor group computations and simple groups, Isomorphism theorems. Series of groups.

Unit III - Advanced Group Theory: (18 Hours)

Symmetry of plane figures, Isometries, Isometries of the plane, Finite groups of orthogonal operators onthe plane. Group actions on a set, Applications of group actions to counting, Cayley's theorem, Theclass equation, p-Groups, Conjugation in the symmetric group, Normalizers, The Sylow theorems, The groups of order 12.

Unit IV - Rings and Fields: (6 Hours)

Definitions of rings, subrings, integral domains, fields and their basic properties, Homomorphisms andFactor Rings, Prime and Maximal Ideals. Fields of quotients of an integral domain, Rings of Polynomials.

References

[1] J. B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Addison Wesley, 2003.
[2] Michael Artin, *Algebra*, 2nd Ed., Prentice Hall of India, 2013.
[3] I. N. Herstein, *Topics in Algebra*, 2nd Ed., John Wiley & Sons, 2006.
[4] Joseph A. Gallian, *Contemporary Abstract Algebra*, 8th Ed., Cengage Learning India, 2013.
[5] Paul B. Garrett, *Abstract Algebra*, CRC press, 2007.
[6] Thomas W. Hungerford, *Algebra,* Springer, 2004.
[7] David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., Wiley, 2004.
[8] Serge Lang, *Algebra*, 3rd Ed., Springer, 2005.

PGMTH 102	Linear Algebra -I	4 Credits (48 hours)

Course Outcome: Students will have the knowledge and skills to explain the fundamental concepts of Matrix Operations, Vector spaces, Linear Operators, Eigenvectors, The characteristic polynomial, Jordan form, the concepts Orthogonal matrices and Rotations, The matrix exponential, which is usedto solve differential equations arising in the fields like physics, chemistry, economics and also inbiology. This course is a foundation for next course in Linear algebra.

Course Specific Outcome: At the end of the course students will have the knowledge and skills

- To develop techniques to work with matrices, Jordan form etc
- To enhance one's skills in applying matrices to solve differential equations
- To acquaint knowledge in the theory of vector spaces
- To acquaint knowledge in the theory of linear transformations.

Unit I - Matrix Operations:

Recapitulation of the basic operations, Block multiplication, Matrix units, Row reduction, The matrixtranspose, Permutation matrices, Determinants, Other formulas for Determinant, The Cofactor matrix.

(12 Hours)

Unit II - Vector Spaces:

Subspaces of R^n, Fields, Vector Spaces, Bases and dimension. Computing with bases, Direct sums, Infinite Dimensional spaces.

(12 Hours)

Unit III - Linear Operators:

The dimension formula, The matrix of a linear transformation, Linear Operators, Eigenvectors, Thecharacteristic polynomial, Triangular and Diagonal forms. Jordan form.

(18 Hours)

Unit IV - Applications of Linear Operators:

Orthogonal matrices and Rotations, Cayley-Hamilton Theorem, The matrix exponential.

(6 Hours)

References

[1] Michael Artin, *Algebra*, 2nd Ed., Prentice Hall of India, 2013.
[2] Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Ed., Prentice Hall ofIndia, 2014.
[3] K. Hoffmann and R. Kunz, *Linear Algebra*, 2nd Ed., Prentice Hall of India, 2013.
[4] Serge Lang, *Linear Algebra*, Addison Wesley, London, 1970.
[5] Larry Smith, *Linear Algebra*, 3rd Ed., Springer Verlag, 1998.
[6] Gilbert Strang, *Linear Algebra and its Applications*, 4th Ed., Cengage Learning, 2006.
[7] S. Kumaresan, *Linear Algebra - A Geometric Approach*, PHI, 2003.

PGMTH 103	Real Analysis-I	4 Credits (48 hours)

Course Outcome: Students will have the knowledge and skills to explain the fundamental concepts of the real number system, Perfect sets, Connected sets, explain the concepts of convergent sequences, subsequences, Cauchy sequences, Series, the derivative of a real function, Mean value theorems, L'Hospital's rule, Taylor's theorem and its applications, differential equations and more generally in mathematical analysis.

Course Specific Outcome: At the end of the course students will have the knowledge and skills

- To study the real number system and their properties in detail
- To develop skills to work with sequences in arbitrary metric spaces
- To develop skills to work with series of real numbers
- To study the concepts of continuous functions and differentiable functions.

Unit I - The Real and Complex Number System: **(16 Hours)**
Introduction, Ordered sets, Fields, The real field, The extended real number system, The complex field,Euclidean spaces, Inequalities.
Basic Topology: Finite, countable and uncountable sets, Metric spaces, Compact sets, Perfect sets, Connected sets.

Unit II - Numerical Sequences and Series: **(12 Hours)**

Convergent sequences, Subsequences, Cauchy sequences, Upper and lower limits, some special sequences, Series, Series of non-negative terms, The number *e*, The root and ratio tests, Power series, Summation by parts, Absolute convergence, Addition and multiplication of series. Rearrangements.

Unit III - Continuity: **(12 Hours)**

Limits of functions, Continuous functions, Continuity and compactness, Continuity and connectedness,Discontinuities, Monotonic functions, Infinite limits and limits at infinity.

Unit IV - Differentiation:

The derivative of a real function, Mean value theorems, The continuity of derivatives, L'Hospital's rule,Derivatives of higher order, Taylor's theorems, Differentiation of vector valued functions.
(8 Hours)

References

[1] Walter Rudin, *Principles of Mathematical Analysis*, 3rd Ed., McGraw Hill, 1976.
[2] Robert. G. Bartle, *The Elements of Real Analysis*, 2nd Ed., Wiley International Ed., New York, 1976.
[3] T. M. Apostol, *Mathematical Analysis*, 2nd Ed., Narosa Publishers, 1985.
[4] Ajith Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press, 2014.
[5] R. R. Goldberg , *Methods of Real Analysis*, 2nd Ed., Oxford & I. B. H. Publishing Co., New Delhi,1970.
[6] N. L. Carothers, *Real Analysis*, Cambridge University Press, 2000.
[7] Russel A. Gordon, *Real Analysis - A First Course*, 2nd Ed., Pearson, 2011.

PGMTS 104	Numerical Analysis	4 Credits (48 hours)

Prerequisite: Knowledge of Mathematics at Under-Graduate Level.

Course Outcome: Students will have the knowledge and skills to explain the fundamental concepts of Numerical analysis, in the areas of mathematics and computer science that creates, analyzes, and implements algorithms for obtaining numerical solutions to problems involving continuous variables. Such problems arise throughout the natural sciences, social sciences, engineering, medicine and business.

Course Specific Outcome: At the end of the course students will have the knowledge and skills

- Obtain the solutions of Transcendental and Polynomial Equations
- Solve by Direct methods and Iteration methods for solving system of equations
- Apply Hermite Interpolation
- Solve problems using interpolation
- Solve Ordinary Differential Equations using Numerical methods.

Unit I - Transcendental and Polynomial Equations: (12 Hours)

Introduction, The bisection method, Iteration methods based on first degree equation, Iteration methods based on second degree equation, Rate of convergence, Rate of convergence of Secant and Newton-Raphson method. Iteration methods - First order method, Second order method, Higher ordermethods. Polynomial equations, Descartes' Rule of Signs, The Birge-Vieta method.

Unit II - System of Linear Equations and Eigenvalue problems: (12 Hours)

Introduction, Direct methods-Gauss elimination method, Gauss-Jordanmethod, Triangularization method, Cholesky method. Iteration methods - Jacobi iteration method, Gauss-Seidel iteration method, Convergence analysis, Eigenvalues and eigenvectors. The powermethod.

Unit III - Interpolation and Approximation: (12 Hours)

Introduction, Lagrange and Newton interpolations, Linear and Higher order interpolation, Finite difference operators, Interpolating polynomials using finite differences, Hermite interpolation, Approximations.

Unit IV - Numerical Differentiation: (12 Hours)

Introduction, Methods based on Interpolation, Methods based on finite differences, Methods based on undetermined co-effcients, Extrapolation methods. Numerical Integration: Methods based on Interpolation, Newton-Cotes methods, Composite Integration Methods.

References

[1] M. K. Jain, S. R. K. Iyengar, R. K. *Jain, Numerical Methods for Scientifc and Engineering Computation*,6th Ed., New Age International, 2012.

[2] C. F. Gerald and P. O. Wheatly, *Applied Numerical Analysis*, Pearson Education, Inc., 1999.

[3] A. Ralston and P. Rabinowitz, *A First Course in Numerical Analysis*, 2nd Ed., McGraw - Hill, NewYork, 1978.

[4] K. Atkinson, *Elementary Numerical Analysis*, 2nd Ed., John Wiley and Sons, Inc., 1994.

[5] P. Henrici, *Elements of Numerical Analysis*, John Wiley and Sons, Inc., New York, 1964.

PGMTS 105	Theory of Combinatorics	4 Credits (48 hours)

Prerequisite: Knowledge of Mathematics at Under-Graduate Level.

Course Outcome: Students will have the knowledge and skills to explain the fundamental concepts and development of Elementary Number Theory using axioms, definitions, examples, theoremsand their proofs.

Course Specific Outcome: At the end of the course students will have the knowledge and skills to:

- Apply methods of solving Linear Diophantine equations, Primality testing and factorization.
- Find the Dirichlet product of arithmetical functions, Dirichlet inverses.
- Solve the Linear congruences, Polynomial congruences modulo p, Simultaneous linear congruences, Simultaneous non-linear congruences, and congruences modulo prime powers.
- Apply the properties of Legendre's symbol , Gauss lemma,
- Understand the Pythagorean triples and their classification, Fermat's Last Theorem.
- Solve Pell's equation by continued fractions.

Unit I - Divisibility and Primes: (12 Hours)

Recapitulation of Division algorithm, Euclid's algorithm, Least Common Multiples, Linear Diophantine equations. Prime numbers and Prime-power factorisations, Distribution of primes, Fermat and Mersenne primes, Primality testing and factorization.

Arithmetical Functions: The Mobius function and its properties, Euler function, examples and properties, The Dirichlet product of arithmetical functions, Dirichlet inverses and the Mobius inversion formula.

Unit II - Congruences: (12 Hours)

Recapitulation of basic properties of congruences, Residue classes and complete residue systems, Linear congruences. Reduced residue systems and the Euler-Fermat theorem, Polynomial congruencesmodulo *p* and Langrange's theorem, Simultaneous linear congruences, Simultaneous non-linear congruences, An extension of Chinese Remainder Theorem, Solving congruences modulo prime powers.

Unit III - Quadratic Residues and Quadratic Reciprocity Law: (12 Hours)

Quadratic residues, Legendre's symbol and its properties, Euler's criterion, Gauss lemma, The quadratic reciprocity law and its applications, The Jacobi symbol, Applications to Diophantine equations.

Unit IV - Sums of squares, Fermat's last theorem and Continued fractions: (12 Hours)

Sums of two squares, Sums of four squares, The Pythagoras theorem, Pythagorean triples and their classification, Fermat's Last Theorem (Case $n = 4$).

Recapitulation of Finite continued fractions, Infinite continued fractions, Representation of irrational numbers, Periodic continued fractions and quadratic irrationals. Solution of Pell's equation by continued fractions.

References

[1] G. A. Jones and J. M. Jones, *Elementary Number Theory*, Springer UTM, 2007.
[2] Tom M. Apostol, *Introduction to Analytic Number Theory*, Springer, 1989.
[3] David M. Burton, *Elementary Number Theory*, 7th Ed., McGraw-Hill, 2010.
[4] Niven, H.S. Zuckerman & H.L. Montgomery, *Introduction to the Theory of Numbers*, Wiley, 2000.
[5] H. Davenport, *The Higher Arithmetic*, Cambridge University Press, 2008.

PGMTL 106	Lab - 1	2 Credits (2 hours lab /week)

Practicals for I Semester

Mathematics practical with Free and Open-Source Software (FOSS) tools for computer programs

Course Outcome/Specific Outcome: Students will have the knowledge and skills to implement the programmes listed below in the Scilab programming language. Student are expected to apply these programming skills of computation in science and Engineering.

1) Program to accept three integers and print the largest among them and program to check whethera given integer is even or odd and also positive or negative.
2) Program to find roots of a quadratic equation.
3) Program to perform arithmetic operations using switch case.
4) Program to convert binary number to decimal number and decimal number to binary number.
5) Program to calculate factorial of a number and program to print Fibonacci numbers.
6) Program to search an element in the array.
7) Program to arrange a set of given integers in an ascending order and print them.
8) Program to find row sum and column sum of a matrix.
9) Program to find the Transpose, Trace and Norm of a matrix.
10) Program to find sum, difference and product of two matrices.
11) Program to test whether a given integer is a prime and program to generate prime numbersbetween two give numbers.
12) Program to find the Armstrong Number between two given numbers and program to test whethera given number is Palindrome or not.

II Semester

PGMTH 201	Algebra - II	4 Credits (48 hours)

Course Outcome: Students will have the knowledge and skills to apply the advanced topics viz., Unique factorization domains, Field theory and Galois Theory in Coding theory and Cryptography, and also in diverse situations in physics, chemistry and engineering etc.

Course Specific Outcome: At the end of the course students will have the knowledge and skills to **e**xplain, demonstrate accurate and efficient use of the following advanced topics in various situations -

- Unique factorization domains
- Euclidean domains
- Fields(including finite fields), algebraically closed fields
- The fundamental theorem of algebra. Galois Theory.

Unit I - Factoring:

Unique factorization domains, Euclidean domains, Content of polynomials, Primitive polynomials,Gauss lemma, Unique factorization in R[x], where R is a U.F.D., Irreducibility test mod *p*, Eisenstein's criterion, Gauss primes.

(16 Hours)

Unit II - Fields:

Algebraic and transcendental elements, The degree of a field extension, Finding the irreducible polynomial, Ruler and compass constructions, Isomorphism of field extensions, Adjoining roots, Splitting fields, Finite fields, Primitive elements, Algebraically closed fields, The fundamental theorem of algebra.

(20 Hours)

Unit III - Galois Theory:

Automorphisms and Fields, Separable Extensions, Galois Theory, Illustrations of Galois Theory,Cyclotomic Extensions, Insolvability of the Quintic.

(12 Hours)

References

[1] Michael Artin, *Algebra*, 2nd Ed., Prentice Hall of India, 2013.
[2] J. B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Addison Wesley, 2003.
[3] I. N. Herstein, *Topics in Algebra*, 2nd Ed., John Wiley & Sons, 2006.
[4] Joseph A. Gallian, *Contemporary Abstract Algebra*, 8th Ed., Cengage Learning India, 2013.
[5] Paul B. Garrett, *Abstract Algebra*, CRC press, 2007.
[6] Thomas W. Hungerford, *Algebra*, Springer, 2004.
[7] David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., Wiley, 2004.
[8] Serge Lang, *Algebra*, 3rd Ed., Springer, 2005.

PGMTH 202	Real Analysis - II	4 Credits (48 hours)

Course Outcome: Students will have the knowledge and skills to demonstrate a competence in formulating, analysing and solving problems in several core areas of higher level Real Analysis, Develop skills to work with Riemann Integrals, sequences and series of functions and their convergence, approximation theory like Weierstrass Theorem, differentiation of several variable functions.

Course Specific Outcome: At the end of the course Students will have the knowledge and skills to **e**xplain Demonstrate accurate and efficient use of the following advanced topics in various situations -

- The Riemann-Stieltjes Integral, rectifiable curves, improper integrals
- Sequences and series of functions, uniform convergence and continuity
- Equicontinuous families of functions
- The Stone-Weierstrass theorem
- Functions of several variables: Differentiation, the contraction principle, the inverse functiontheorem, the implicit function theorem.

Unit I - The Riemann-Stieltjes Integral:

Definition and existence of integrals, Properties of integral, Integration and differentiation, Integrationof vector-valued functions, Rectifiable curves.

Improper Integrals: Definition, Criteria for convergence, Interchanging derivatives and integrals.

(20 Hours)

Unit II - Sequences and Series of Functions:

Discussion of main problem, Uniform convergence, uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, The Stone-Weierstrass theorem.

(16 Hours)

Unit III - Functions of Several Variables:

Differentiation, The contraction principle, The inverse function theorem, The implicit functiontheorem.

(12 Hours)

References

[1] Walter Rudin, *Principles of Mathematical Analysis*, 3rd Ed., McGraw Hill, 1976.

[2] Robert. G. Bartle, *The Elements of Real Analysis*, 2nd Ed., Wiley International Ed., New York, 1976.

[3] Serge Lang, *Analysis* I, Addison Wesley Publishing Company, 1968.

[4] T. M. Apostol, *Mathematical Analysis*, 2nd Ed., Narosa Publishers, 1985.

[5] Ajith Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press, 2014.

[6] R. R. Goldberg , *Methods of Real Analysis*, 2nd Ed., Oxford & I. B. H. Publishing Co., New Delhi,1970.

[7] N. L. Carothers, *Real Analysis*, Cambridge University Press, 2000.

[8] Russel A. Gordon, *Real Analysis - A First Course*, 2nd Ed., Pearson, 2011.

PGMTH 203	Topology	4 Credits (48 hours)

Course Outcome: To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.

Course Specific Outcome: At the end of the course Students will have the knowledge and skills to **e**xplain, demonstrate accurate and efficient use of the following advanced topics in various situations -

- Elementary concepts, Open bases and open subbases, Weak topologies
- The function algebras $C(X, \mathrm{R})$ and $C(X, \mathrm{C})$
- Countability axioms and Separability axioms
- Urysohn's lemma, Tietze extension theorem, and the Urysohn imbedding theorem
- Connected spaces, the components of a space, totally disconnected spaces, locally connected spaces.

Unit I - Topological Spaces:

The definition and some examples, Elementary concepts, Open bases and open subbases, Weaktopologies, The function algebras *C(X, R*) and *C(X, C).*

(15 Hours)

Unit II - Compactness:

Compact Spaces, Product spaces, Tychonoff's theorem.

(10 Hours)

Unit III - Separation:

T_1-Spaces and Hausdorff spaces, Completely regular spaces and Normal spaces, Urysohn's lemma and Tietze extension theorem, The Urysohn imbedding theorem.

(13 Hours)

Unit IV - Connectedness:

Connected spaces, The components of a space, Totally disconnected spaces, Locally connected spaces.

(10 Hours)

References

[1] G. F. Simmons, *Introduction to Topology and Modern Analysis*, Tata McGraw-Hill, 2004.

[2] J. R. Munkres, *Topology*, 2nd Ed., Pearson Education, Inc, 2000.

[3] S. Willard, *General Topology*, Addison Wesley, New York, 1968.

[4] J. Dugundji, *Topology*, Allyn and Bacon, Boston, 1966.

[5] J. L. Kelley, *General Topology*, Van Nostrand Reinhold Co., New York, 1955.

PGMTS 204	Linear Algebra - II	4 Credits (48 hours)

Prerequisite: Knowledge of syllabus prescribed for the course MTH 402 (Linear Algebra- I).

Course Outcome: Students will have the knowledge and skills to demonstrate a competence in formulating, analysing and solving problems in several core areas of higher level of Linear Algebra concepts- Bilinear, Symmetric forms, orthogonal basis, spectral theorems, theory of modules in solving integer system, Hilbert basis theorem, Structure theorem which have plenty of applications in Fourier analysis, Wavelet Theory, Mathematical Physics and Chemistry.

Course Specific Outcome: At the end of the course students will have the knowledge and skills to **e**xplain, demonstrate accurate and efficient use of the following advanced topics in various situations –

- Bilinear Forms, Hermitian forms
- Orthogonal Projection
- The spectral theorem
- Skew symmetric forms, Modules, Free modules
- Diagonalizing Integer Matrices
- Noetherian Rings
- The structure theorem for abelian groups
- Application to linear operators.

Unit I - Bilinear Forms:

Bilinear forms, Symmetric forms, Hermitian forms, Orthogonality, Orthogonal Projection, Euclidean andHermitian spaces, The spectral theorem, Skew symmetric forms, Summary of results in matrix notation. **(24 Hours)**

Unit II - Linear Algebra in a Ring:

Modules, Free modules, Diagonalizing Integer Matrices, Submodule of free modules, Generators andRelations, Noetherian Rings, The structure theorem for abelian groups, Application to linear operators. **(24 Hours)**

References

[1] Michael Artin, *Algebra*, 2nd Ed., Prentice Hall of India, 2013.
[2] Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Ed., Prentice Hall ofIndia, 2014.
[3] K. Hoffmann and R. Kunz, *Linear Algebra*, 2nd Ed., Prentice Hall of India, 2013.
[4] Serge Lang, *Linear Algebra*, Addison Wesley, London, 1970.
[5] Larry Smith, *Linear Algebra*, 3rd Ed., Springer Verlag, 1998.
[6] Gilbert Strang, *Linear Algebra and its Applications*, 4th Ed., Cengage Learning, 2006.
[7] S. Kumaresan, *Linear Algebra - A Geometric Approach*, PHI, 2003.

PGMTS 205	Ordinary Differential Equations	4 Credits (48 hours)

Prerequisite: Knowledge of syllabi prescribed for the courses MTH 402 (Linear Algebra -I) and MTH 403(Real Analysis- I).

Course Outcome: Students will have the knowledge and skills of solving ordinary differential equations,finding power series solutions of ordinary differential equations.

Course Specific Outcome: At the end of the course Students will have the knowledge and skills to **e**xplain, demonstrate accurate and efficient use of the following advanced topics in various situations:

- Notion of Linear dependence and the Wronskian
- The Basic theory for linear equations
- Solving differential equations using Power Series method
- The Legendre polynomials, Bessel's functions
- Solving Systems of first order equations
- Existence and uniqueness theorem
- The fundamental matrix, non-homogeneous linear systems, linear systems with periodiccoefficients.

Unit I - Linear Differential Equations of Higher Order: (12 Hours)

Linear dependence and the Wronskian, Basic theory for linear equations, Method of variation of parameters, Reduction of n^{th} order linear homogeneous equation, Homogeneous and non-homogeneous equations with constant coefficients.

Unit II - Solutions in Power Series: (18 Hours)

Second order linear equations with ordinary points, Legendre equation and Legendre polynomials,Second order equations with regular singular points, Bessel equation.

Unit III - Systems of Linear Differential Equations: (10 Hours)

Systems of first order equations, Existence and uniqueness theorem. The fundamental matrix, Non-homogeneous linear systems, Linear systems with periodic coefficients.

Unit IV - Existence and Uniqueness of solutions: (8 Hours)

Equations of the form $x' = f(t, x)$, Method of successive approximation, Lipschitz condition, Picard's theorem, Non uniqueness of solutions, Continuation of solutions.

References

[1] S. G. Deo and V. Raghavendra, *Ordinary Differential Equations and Stability Theory*, Tata McGraw Hill,1980.

[2] A. Coddington, *An Introduction to Ordinary Differential Equations*, Prentice Hall of India, 2013.

[3] A. Coddington and N. Levinson, *Theory of Ordinary Differential Equations*, Krieger, 1984.

[4] M. W. Hirsh and S. Smale, *Differential Equations, Dynamical Systems and Linear Algebra*, AcademicPress, New York, 1974. 5. V. I. Arnold, Ordinary Differential Equations, MIT Press, Cambridge, 1981.

[5] Shepley L. Ross, *Differential Equations*, Wiley, 200

VPGMTL 207	Lab - 2	2 Credits (2 hours lab /week)

Practicals for II Semester

Mathematics practicals with Free and Open Source Software (FOSS) tools for computer programs

Course Outcome/Specific Outcome: Students will have the knowledge and skills to implement the programmes listed below in the Scilab programming language. They can be expected to apply these programming skills of computation in science and Engineering.

1) Program to find solution to a system of linear equations by matrix inversion method (check for allconditions on input matrix).
2) Program to find solution to a system of linear equations by Cramer's rule (check for all conditionsoninput matrix).
3) Program to find area of one of the geometric figures (circle, triangle, rectangle and square) using switch statements.
4) Program to implement Newton Gregory Forward Difference method.
5) Program to implement Lagrange interpolation polynomial.
6) Program to find the value of a function by using Hermite interpolation method.
7) Program to plot a neat labeled graph of elementary functions on the same plane.
8) Program to obtain the graph of plane curves - cycloid and astroid in separate figure on a single run.
9) Program to obtain a neat labeled graph of space curves - elliptical helix and circular helix inseparatefigure on a single run.
10) Program to obtain a neat labeled graph of surfaces - elliptic paraboloid and hyperbolic paraboloidinseparate figure on a single run.
11) Program to animate the plotted curves.
12) Program to find extreme values of functions of a single variable.

PGMTOE 207	Discrete Mathematics and Applications	3 Credits (36 hours)

Prerequisite: Basic Mathematics up to XII/PU.

Course Outcome: Students will have the knowledge and skills to explain the concepts of Discrete Mathematics and to develop logical thinking and its application to computer science, to enhance one's skills in solving real life problems related to counting, by applying various counting techniques, to illustrate applications of Boolean algebra and group theory in designing logic gates and coding theory.

Course Specific Outcome:
At the end of the course students will have the knowledge and skills to:

- Apply basic number theory concepts like divisibility, modular arithmetic in solving congruences,changing the base of number system and their usage in cryptography.
- Solve many real life problems related to counting by the use of special tools like recurrencerelationsand generating functions.
- Design and simplify the logic gate networks by using lattices and Boolean algebra.
- Apply concept of groups in generating binary coding, decoding and also in error detection anderror correction in the binary coding system.

Unit I - Number Theory and Cryptography:

Divisibility and Modular Arithmetic, Integer Representations and Algorithms, Primes and Greatest Common Divisors, Solving Congruences, Applications of Congruences, Cryptography.

(8 Hours)

Unit II - Counting Techniques:

The Basics of Counting, The Pigeon-hole Principle, Permutations and Combinations, Binomial Coefficients and Identities, Generalized Permutations and Combinations, Recurrence Relations, Applications of Recurrence Relations, Solving Linear Recurrence Relations, Generating Functions. Principle of Inclusion- Exclusion, Applications of Inclusion-Exclusion.

(12 Hours)

Unit III - Order Relations and Structures:

Product Sets and Partitions, Relations, Properties of Relations, Equivalence Relations, Partially Ordered Sets, Extremal Elements of Partially Ordered Sets, Lattices, Finite Boolean Algebras, Functionson Boolean Algebras, Boolean Functions as Boolean Polynomials.

(8 Hours)

Unit IV - Groups and Coding Theory:

Binary Operations Revisited, Semigroups, Products and Quotients of Semigroups, Groups, Products andQuotients of Groups, Coding of Binary Information and Error Detection, Decoding and Error Correction.

(8 Hours)

References

[2] Kenneth H. Rosen, *Discrete Mathematics and Its Applications*, 7th Ed., Tata Mc-Graw-Hill, 2012.
[3] Bernard Kolman, Robert C. Busby, Sharon Cutler Ross, *Discrete Mathematical Structures*, 3rd Ed., Prentice Hall, 1996.
[4] Grimaldi R, *Discrete and Combinatorial Mathematics*, 5th Ed., Pearson, Addison Wesley, 2004.

Semester wise distribution of credits for M.Sc. Mathematics Programme

SEM	Theory(HC[a])		Theory (SC[b])		Open Elective		Lab	Project	Total Credits
	No. of Courses	Credits	No. of Courses	Credits	No. of Courses	Credits	Credits (SC[b])	Credits (HC[a])	
I	3	4	2	4	-	-	2	-	22
II	3	4	2	4	1	3	2	-	22+3*
III	3	4	2	4	1	3	2	-	22+3*
IV	2	4	2	4	-	-	-	4	20
Total		44		32	-	6	6	4	86+6*

HC[a] - Hard core, SC[b] - Soft core, *Not included for CGPA

Total Hard Core Credits is 44+4=48 (55:81%) and total Soft Core Credits is 32+6=38 (44:19%).