Chaudhary Ranbir Singh University, Jind

(Established by the State Legislature Act 28 of 2014)
(Recognised u/s 2(f) and 12(B) of UGC Act, 1956)

Syllabus
for

Post Graduate Programme

M.Sc. Mathematics

as per NEP-2020
Curriculum and Credit Framework for Postgraduate Programme

With Multiple Entry-Exit, Internship and CBCS-LOCF
With effect from the session 2024-25 (in phased manner)

DEPARTMENT OF MATHEMATICS
FACULTY OF PHYSICAL SCIENCES

CHAUDHARY RANBIR SINGH UNIVERSITY
JIND – HARYANA – INDIA -126102

CC-1 REAL ANALYSIS

With effect from the Session: 2024-25			
Part A – Introduction			
Name of Programme	M.Sc. Mathematics		
Semester	I		
Name of the Course	REAL ANALYSIS		
Course Code	M24-MAT-101		
Course Type	CC		
Level of the course	400-499		
Pre-requisite for the course (if any)	Courses on Real Analysis up to the 299 level		
Course Objectives	The course aims to familiarize the learner with Riemann-Stieltjes integral, uniform convergence of sequences and series of functions, functions of several variables and Fourier series.		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand the concept of Riemann-Stieltjes integral along its properties; integration of vector-valued functions with application to rectifiable curves. CLO 2: Understand and handle convergence of sequences and series of functions; construct a continuous nowhere-differentiable function; demonstrate understanding of the statement and proof of Weierstrass approximation theorem. CLO 3: Understand the concepts of differentiability and continuity of functions of several variables and their relation to partial derivatives; apply the knowledge to prove inverse function theorem and implicit function theorem. CLO 4: To formulate convergence problems of Fourier series, know about the (C,1) summability of Fourier series and apply these notions to prove the well- known Fejer theorem, Bessel"s inequality, Riesz-Fischer theorem, Parseval equality and Riemann-Lebesgue theorem.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4

Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Definition and existence of the Riemann-Stieltjes integral, properties of the integral, integration and differentiation, the fundamental theorem of calculus, integration of vector-valued functions, rectifiable curves. (Scope as in Chapter 6 of „Principles of Mathematical Analysis" by Walter Rudin, Third Edition).	15
II	Sequences and series of functions: Pointwise and uniform convergence of sequences of functions, Cauchy criterion for uniform convergence, Dini"s theorem, uniform convergence and continuity, uniform convergence and Riemann integration, uniform convergence and differentiation. (Scope as in Sections 9.1 to 9.3 of Chapter 9 „Methods of Real Analysis" by R.R. Goldberg). Convergence and uniform convergence of series of functions, Weierstrass M-test, integration and differentiation of series of functions, existence of a continuous nowhere-differentiable function, the Weierstrass approximation theorem (Scope as in Sections 9.4, 9.5, 9.7 of Chapter 9 & Section 10.2 of Chapter 10 of „Methods of Real Analysis" by R.R. Goldberg).	15
III	Functions of several variables: Linear transformations, the space of linear transformations on R^n to R^m as a metric space, open sets, continuity, derivative in an open subset of R^n, chain rule, partial derivatives, continuously differentiable mappings, the contraction principle, the inverse function theorem, the implicit function theorem. (Scope as in relevant portions of Chapter 9 (up to 9.29) of „Principles of Mathematical Analysis" by Walter Rudin, Third Edition)	15
IV	Fourier Series: Formulation of convergence problems, the necessary and sufficient condition for the Fourier series for f at x to converge to f(x), The (C,1) summability of Fourier series, Fejer theorem, The L^2 theory of	15

	Fourier series, Bessel"s inequality, Riesz Fischer theorem, Parseval"s equality, convergence of Fourier series, Riemann-Lebesgue theorem Orthonormal expansions in $L^2[a, b]$, Bessel"s inequality for generalized Fourier series. (Scope as in Chapter 12 of „Methods of Real Analysis" by R.R. Goldberg).	
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1. Walter Rudin, Principles of Mathematical Analysis (3rd Edition) McGraw-Hill, 2013.

2. R.R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing, 2020.

Reference Books:

1. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.

2. Gabriel Klambauer, Mathematical Analysis, Marcel Dekkar, Inc. New York, 1975.

3. A.J. White, Real Analysis; an introduction. Addison-Wesley Publishing Co., Inc., 1968.

4. E. Hewitt and K. Stromberg. Real and Abstract Analysis, Berlin, Springer, 1969.

5. Serge Lang, Analysis I & II, Addison-Wesley Publishing Company Inc., 1969.

6. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi, 4th Edition 2010.

7. D. Somasundaram and B. Choudhary, A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997

CC-2 COMPLEX ANALYSIS

With effect from the Session: 2024-25			
Part A – Introduction			
Name of Programme	M.Sc. Mathematics		
Semester	I		
Name of the Course	COMPLEX ANALYSIS		
Course Code	M24-MAT-102		
Course Type	CC		
Level of the course	400-499		
Pre-requisite for the course (if any)	Courses on Real Analysis up to the 299 level		
Course Objectives	The main objective of the course is to familiarize the learner with complex function theory, analytic functions theory, the Cauchy's theorems, integral formulas, singularities and contour integrations and finally provide a glimpse of Argument principle; Rouche's theorem; Schwarz Lemma.		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand the concepts of limit, continuity, differentiation and integration for functions defined over a complex plane as well as for the elementary functions. CLO 2: Solve the complex integrals of various kinds through the applications of relevant theorems, formulae and power series expansions. CLO 3: Analyse the complex functions with singularities for zeroes and residues at poles and apply the results to solve the improper integrals. CLO 4: Understanding statements and proofs of argument principle and Rouche theorem and apply the knowledge to solve relevant exercises.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	The function of a complex variable, Continuity, Differentiability, Analytic functions and their properties, Cauchy-Reimann equations in cartesian and polar coordinates, Power Series, Radius of convergence, Differentiability of sum function of a power series. (Relevant portions from the book recommended at Sr. No. 1)	15
II	Contour, Complex Integration, Cauchy theorem, Simply/ multiply connected domains, Cauchy integral formula, Extension of Cauchy integral formula for multiply connected domains, Poisson integral formula, Morera's theorem, Cauchy inequality, Liouville theorem. (Relevant portions from the book recommended at Sr. No. 1)	15
III	Taylor theorem, Zeros of an analytic function, Laurent series, Singularities: Isolated singularities and non-isolated singularities, Cassorati-Weierstrass theorem, Limit point of zeros and poles, Maximum modulus principle, Schwarz Lemma. (Relevant portions from the book recommended at Sr. No. 1)	15
IV	Meromorphic functions, Argument principle, Rouche theorem, Fundamental theorem of algebra, Calculus of residues, Cauchy residues theorem, Evaluation of integrals of the types: $\int_0^{2\pi} f(cos\theta, sin\theta)d\theta$, $\int_{-\infty}^{\infty} f(z)dz$, $\int_0^{\infty} f(z)sinmzdz$, $\int_0^{\infty} f(z)cosmzdz$. (Relevant portions from the book recommended at Sr. No. 1)	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		**End Term Examination: 70**	
➢ **Theory**	**30**	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Book:

1. Churchill, R.V. and Brown, J.W., Complex Variables and Applications, Eighth edition; McGraw Hill International Edition, 2009.

Reference books:

1. Ahlfors, L.V., Complex Analysis. McGraw-Hill Book Company, 1979.
2. Conway, J.B., Functions of One complex variable, Narosa Publishing, 2000.
3. Priestly, H.A., Introduction to Complex Analysis, Claredon Press, Orford, 1990.
4. D.Sarason, Complex Function Theory, Hindustan Book Agency, Delhi, 1994.
5. Mark J.Ablewitz and A.S.Fokas, Complex Variables : Introduction & Applications, Cambridge University Press, South Asian Edition, 1998.
6. E.C.Titchmarsh, The Theory of Functions, Oxford University Press, London. 1939.
7. S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.

CC-3 ORDINARY DIFFERENTIAL EQUATIONS - I

With effect from the Session: 2024-25	
Part A – Introduction	
Name of Programme	M.Sc. Mathematics
Semester	I
Name of the Course	ORDINARY DIFFERENTIAL EQUATIONS - I
Course Code	M24-MAT-103
Course Type	CC
Level of the course	400-499
Pre-requisite for the course (if any)	Courses on Differential Equation and Real Analysis up to the 299 level
Course Objectives	The objectives of this course are to study the existence and uniqueness theory of solutions of initial value problems, to study theory of homogeneous and non-homogeneous linear differential equations of higher order in detail, to learn about oscillations of second order differential equations, and solving boundary value problems. The aim of the course is to form a strong foundation in the theory of ordinary differential equations enabling a learner to apply towards problem solving.
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand concepts of an initial value problem and its exact and approximate solutions. Apply the knowledge to prove specified theorems and to solve relevant exercises. CLO 2: Understand the concepts of uniqueness of solutions. Apply the knowledge to specified theorems and to solve relevant exercises. CLO 3: Have a deep understanding of the theory of linear differential equations of higher order by getting knowledge of basic theory, Wronskian theory, fundamental sets and standard theorems related to these topics. CLO 4: Apply methods of reduction of order and variation of parameters to solve linear and nonlinear differential equation respectively and to solve higher order linear differential equation with constant coefficients.

	Theory	Practical	Total
Credits	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Initial value problem and equivalent integral equation, ε-approximate solution. Equicontinuous family of functions, Ascoli-Arzela theorem, Cauchy–Peano existence theorem, Existence and Uniqueness of Solutions, Lipschitz condition.	15
II	Picard-Lindelof theorem for Existence and Uniqueness of Solutions, Solution of initial-value problems by Picard method, Gronwall's inequality, Linear differential systems: Definitions and notations. Linear homogeneous systems, Fundamental set and Fundamental matrix, Linear systems with constant and periodic coefficients.	15

III	Non-homogeneous linear systems, Floquet theory, Higher order equations: Linear differential equations of order n, theory & examples, Linear combination, Linear dependence and independence of solutions. Wronskian theory: Definition, a necessary and sufficient condition for linear dependence and linear independence of solutions of homogeneous linear differential equations.	
IV	More Wronskian theory, Abel's Identity, Reduction of order, non-homogeneous linear differential equations, Variation of parameters, Adjoint equations, Lagrange's Identity and Green's formula.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		**End Term Examination: 70**	
➢ **Theory**	**30**	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1. Earl A. Coddington and Norman Levinson, *Theory of Ordinary Differential Equations*, McGraw Hill Education, 2017.
2. Sheply L. Ross, *Differential Equations*, Wiley, 3rd Edition, 2007.
3. S.G. Deo, V. Raghavendra, Rasmita Kar, V. Lakshmikantham, *Textbook of Ordinary*

Scanned with OKEN Scanner

Differential Equations, Tata McGraw-Hill , 2006.

Reference books;

1.P. Hartman, *Ordinary Differential Equations*, John Wiley & Sons NY, 1971.
2.G. Birkhoff and G.C. Rota, *Ordinary Differential Equations*, John Wiley & Sons, 1978.
3.G.F. Simmons, *Differential Equations*, Tata McGraw-Hill , 1993.
4.I.G. Petrovski, *Ordinary Differential Equations*, Prentice-Hall, 1966.
5.D. Somasundaram, *Ordinary Differential Equations, A first Course*, Narosa Pub., 2001.

CC-4 NUMBER THEORY

With effect from the Session: 2024-25	
Part A – Introduction	
Name of Programme	M.Sc. Mathematics
Semester	I
Name of the Course	Number Theory
Course Code	M24-MAT-104
Course Type	CC
Level of the course	400-499
Pre-requisite for the course (if any)	Courses having contents of number theory up to the level 299
Course Objectives	In this course, typically include exploring fundamental concepts such as prime numbers, congruences, and Diophantine equations. Students learn to analyze divisibility properties, explore advanced topics like modular arithmetic, and delve into algebraic structures such as groups, rings, and fields relevant to number theory. The course aims to develop problem-solving skills through proofs and applications, preparing students for advanced study in mathematics or related fields. Additionally, emphasis is placed on fostering a deeper understanding of theoretical frameworks and cultivating the ability to apply abstract concepts to real-world scenarios within the realm of number theory.
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: To understand Well ordering principle, divisibility, division algorithm. CLO 2: To learn about Linear Diophantine equation, simultaneous linear equations. CLO 3: To be familiar with the Farey sequences, Farey sequences of order n, rational approximations, Hurwitz theorem. CLO 4: To learn about Fermat numbers, Euler's Function and its properties, Euler's generalization of Fermat's theorem.

Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per Week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Well ordering principle, divisibility, division algorithm, G.C.D. (greatest common divisors), L.C.M. (least common multiple), Gauss theorem, primes, perfect number, Euclid's first theorem, Fundamental Theorem of arithmetic or Unique Factorization theorem, Euclid's second theorem.	15
II	Linear Diophantine equation i,e, equation of the type ax + by = c, the necessary and sufficient condition that the linear Diophantine equation has a solution in integer. Example of Linear Diophantine equation, simultaneous linear equation.	17

III	Farey sequences, Farey sequences of order n, rational approximations, Hurwitz theorem, irrational numbers, Geometry of numbers, Minkowski's convex body theorem, Langrange's four square theorem.	14
IV	Fermat numbers, Fermat numbers are relatively prime, properties of Fermat numbers, Fermat's theorem, Wilson's theorem, converse of Wilson's theorem, Euler's function and its properties, multiplicative function, Euler's generalization of Fermat's theorem.	14
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		**End Term Examination: 70**	
➢ **Theory**	**30**	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1. An introduction to the Theory of Numbers Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery, John Wiley & Sons(Asia)Pte.Ltd. 1991.

Reference books;

1.Number Theory, An introduction to mathematics, Second edition, W.A. Coppel, Springer 2009.

2. G. H. Hardy and E. M. Wright, An introduction to the Theory of Nmubers, Oxford University, 2008.

3. Burton , D. M. *Elementary Number Theory*, Tata McGraw Hill Publishing House, 2006.

CC-5 ABSTRACT ALGEBRA

With effect from the Session: 2024-25	
Part A – Introduction	
Name of Programme	M.Sc. Mathematics
Semester	I
Name of the Course	ABSTRACT ALGEBRA
Course Code	M24-MAT-105
Course Type	CC
Level of the course	400-499
Pre-requisite for the course (if any)	Courses on Algebra up to the level 299.
Course Objectives	The concept of a group is surely one of the central ideas of Mathematics. The main aim of this course is to introduce Sylow theory and some of its applications to groups of smaller orders. An attempt has been made in this course to strike a balance between the different branches of group theory, abelian groups, nilpotent groups, finite groups, infinite groups and to stress the utility of the subject. A study of modules, submodules, quotient modules, finitely generated modules etc. is promised in this course. Similar linear transformations, Nilpotent transformations and related topics are also included in the course.
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand concepts of normal subgroup, quotient group, isomorphism, normal series, composition series, solvable group, refinement theorem. CLO 2: Learn about nilpotent group, cyclic decomposition, alternating group A_n, Sylow"s theorem and its applications. CLO 3: Understand concepts of modules, submodules, direct sum, R-homomorphism, quotient module, completely reducible modules, free modules. CLO 4: Learn about similar linear transformation, triangular form, nilpotent transformation, primary decomposition theorem.

Credits	Theory	Practical	Total

	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Normal subgroup, quotient group, normalizer and centralizer of a non-empty subset of a group G, commutator subgroups of a group. first, second and third isomorphism theorems (only statement), class equation of a finite group G. normal series, composition series, Jordan Holder theorem, Zassenhaus lemma, Scheier's refinement theorem, solvable group.	15
II	Nilpotent group, Cyclic decomposition, even and odd permutation, Alternation group A_n, Cauchy's theorem, Sylow's first, second and third theorems and its applications to group of smaller orders. groups of order p^2 and pq (q>p).	15
III	Modules, submodules, direct sums, finitely generated modules, cyclic module. R-homomorphism, quotient module, completely reducible modules, Schur"s lemma, free modules.	15
IV	Similar linear transformation, invariant subspaces of vector spaces, reduction of a linear transformation to triangular form, nilpotent transformation, index of nilpotency of a nilpotent transformation. Cyclic subspace with respect to a nilpotent transformation, uniqueness of the invariants of a nilpotent transformation. Primary decomposition theorem.	15

	transformation, rational canonical form of a linear transformation and its elementary divisors, uniqueness of elementary divisors. (6.4. to 6.7 of recommended book of Sr. No. 3).	
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ **Theory**	**30**	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1 P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul, Basic Abstract Algebra (Second edition), CambridgeUniversity Press, 2012.

Reference books;

1.Surjit Singh and Quazi Zameeruddin : Modern Algebra ,Vikas Publishing House, 2021.
2. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

PC-I PRACTICAL-I

With effect from the Session: 2024-25			
Part A – Introduction			
Name of the Programme	M.Sc. Mathematics		
Semester	I		
Name of the Course	Practical-I		
Course Code	M24-MAT-106		
Course Type	PC		
Level of the course	400-499		
Pre-requisite for the course (if any)			
Course objectives	This is a laboratory course and objective of this course is to acquaint the students with the coding skills in C programming language for problem solving. Also, some problem solving techniques based on papers M24-MAT-101 to M24-MAT-105 will be taught.		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	CLO 1: Solve practical problems related to theory courses undertaken in the Semester-I from application point of view. CLO 2: Know syntax of expressions, statements, structures and to write source code for a program in C. CLO 3: Edit, compile and execute source programs for desired results. CLO 4: Debug, verify/check and to obtain output of results.		
	Theory	Practical	Total
Credits	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	

Part B- Contents of the Course	
Practicals	**Contact Hours**
Practical course will consist of two components Part-A and Part-B. The examiner will set 5 questions at the time of practical examination asking 2 questions from the Part-A and 3 questions from the Part-B by taking course learning outcomes (CLO) into consideration. The examinee will be required to solve one problem from the Part-A and to write and execute 2 questions from	120

the Part-B.	
Part-A Problems based on the theory courses M24-MAT-101 to M24-MAT-105 will be solved in this part and their record will be maintained in the Practical Note Book. Direct results and theorems will not be asked rather exercises or numerical problems or applied problems based on the theory parts will be done, as identified or given by the teacher concerned.	30
Part-B The following practicals will be done using the programming language C and record of those will be maintained in the practical Note Book: 1. Use of nested *if.. .else* in finding the smallest of four or more numbers. 2. To find if a given 4-digit year is a leap year or not. 3. To compute AM, GM and HM of three given real values. 4. To invert the order of digits in a given positive integral value. 5. Use series sum to compute sin(x) and cos(x) for given angle x in degrees. Then, check error in verifying $\sin^2 x+\cos^2(x) = 1$ or other such T-identities. 6. Verify $\sum n^3 = \{\sum n\}^2$, (where n=1, 2,…, m) & check that prefix and postfix increment operator gives the same result. 7. Compute simple interest and compound interest for a given amount, time period, rate of interest and period of compounding. 8. Program to multiply two given matrices in a user defined function. 9. Calculate standard deviation for a set of values {x(j), j = 1, 2,..., n} having the corresponding frequencies {f(j), j = 1,2,...,n}. 10. Write the user-defined function to compute GCD of two given values and use it to compute the LCM of three given integer values. 11. Compute GCD of 2 positive integer values using recursion / pointer to pointer. 12. Check a given square matrix for its positive definite/ negative definite forms. 13. To find the inverse of a given non-singular square matrix. 14. To convert a decimal number to its binary representation and vice-versa. 15. To solve an algebraic or transcendental equation by Newton-Raphson and Regula-Falsi methods. 16. To solve initial value problems by Runge-Kutta methods. 17. To solve a system of linear equations by Gauss-Seidel method. 18. To solve a definite integral using Simpson rules. 19. Use array of pointers for alphabetic sorting of given list of English words. 20. To search a number in an array by binary search method.	90 (Lab hours include instructions for writing programs in C and demonstration by a teacher and for run the programs on computer by students.)
Suggested Evaluation Methods	

Internal Assessment: 30		End Term Examination: 70	
➢ **Practicum**	**30**	➢ **Practicum**	**70**
• Class Participation:	5	Lab record, Viva-Voce, write-up and execution of the programs	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	10		
• Mid-Term Examination:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Kanetker, Yashwant, *"Let us C"*, BPB Publications, 15th Edition.
2. Gottfried, Byron, *"Programming with C"*, Tata McGraw Hill, 2nd Edition.

Reference books;

1.Kernighan, B. W., Ritchie, D. M., *"The C Programming Language"*, PHI, 2nd Edition.
2.Koffman, Hanly, *"Problem Solving and Program Design in C"*, Pearson, 8th Edition.

SEMINAR

With effect from the Session: 2024-25	
Name of the Programme	M.Sc. Mathematics
Semester	I
Name of the Course	Seminar
Course Code	M24-MAT-107
Course Type: (CC/DEC/PC/SEM/CHM/OEC/EEC)	SEM
Level of the course	400-499
Course objectives	The objectives of this course are self-learning, understanding a topic in detail, exploring library and e-resources, comprehension of the subject/topic, investigating a problem, knowledge of ethics, effective communication and life-long learning.
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Identify an area of interest and to select a topic therefrom realizing ethical issues related to one"s work and unbiased truthful actions in all aspects of work and to develop research aptitude. CLO 2: Have deep knowledge and level of understanding of a particular topic in core or applied areas of Mathematics, imbibe research orientation and attain capacity of investigating a problem. CLO 3: Obtain capability to read and understand mathematical texts from books/journals/e-contents, to communicate through write up/report and oral presentation. CLO 4: Demonstrate knowledge, capacity of comprehension, precision, defence, capability to work independently and tendency towards life-long learning.
Credits	Seminar
	2
Teaching Hours per week	2
Max. Marks	50
Internal Assessment Marks	0

End Term Exam Marks	50
Examination Time	1 hour

Instructions for Examiner: Evaluation of the seminar will be done by the internal examiner(s) on the parameters as decided by staff council of the department. There will be no external examination/viva-voce examination.

Each student will select a topic of one"s choice, will get approval from the concerned teacher incharge, give sittings in library so as to read different books and journals, and e-resources, prepare a seminar document, present before the group and its teacher incharge for one hour. The evaluation of the seminar will be done by the concerned teacher incharge by taking into account the following:

i. Subject knowledge.
ii. Degree of difficulty, research aptitude and knowledge updation in terms of choice of the topic.
iii. Contents of the seminar report.
iv. Presentation, Communication and. Language skills
v. Response to questions.

CC-6 FIELD THEORY

With effect from the Session: 2024-25			
Part A – Introduction			
Name of Programme	M.Sc. Mathematics		
Semester	II		
Name of the Course	FIELD THEORY		
Course Code	M24-MAT-201		
Course Type	CC		
Level of the course	400-499		
Pre-requisite for the course (if any)	Courses on Algebra up to the level 299		
Course Objectives	As suggested by the name of the course itself, some of the advanced topics of abstract algebra will be taught to the students in this course including field extensions, finite fields, normal extensions, finite normal extensions and splitting fields. A study of Galois extensions, Galois groups of polynomials, Galois radical extensions will also be taught.		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand concepts of irreducible polynomial, Eisenstein criterion, field extension, algebraic and transcendental extension, algebraically closed field. CLO 2: Have deep understanding of Splitting fields, normal extension, multiple roots, prime field, finite field and separable extension. CLO 3: Learn about automorphism groups, fixed field, Dedekind lemma, fundamental theorem of Galois theory, roots of unity, Cyclotomic polynomial and cyclic extension. CLO 4: Have deep understanding of polynomials solvable by radicals, symmetric functions, ruler and compass construction.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		
Part B- Contents of the Course			
Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each			

unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Irreducible polynomials, Eisenstein criterion, Gauss lemma. Field extension, algebraic and transcendental extension, degree of extension algebraic closure and algebraically closed field.	15
II	Splitting field, degree of extension of splitting field. Normal extension multiple roots, prime field, characterization of prime field, finite field separable extension.	15
III	Automorphism group, fixed field, Dedekind lemma, Galois groups of polynomials, Galois extension, fundamental theorem of Galois theory fundamental theorem of algebra, roots of unity.	15
IV	Solvability of polynomials by radicals over Q. Symmetric functions and elementary symmetric functions. Construction with ruler and compass only.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 2012.

Reference Books:

1. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.

2. Surjit Singh and Quazi Zameeruddin, Modern Algebra, Vikas Publishing House, 2021.

3. Patrick Morandi, Field and Galois Theory, Springer 1996.

CC-7 MEASURE AND INTEGRATION

With effect from the Session: 2024-25			
Part A – Introduction			
Name of Programme	M.Sc. Mathematics		
Semester	II		
Name of the Course	MEASURE AND INTEGRATION		
Course Code	M24-MAT-202		
Course Type	CC		
Level of the course	400-499		
Pre-requisite for the course (if any)	Courses on Real Analysis up to the 299 level		
Course Objectives	The main objective is to familiarize the learner with Lebesgue outer measure, measurable sets, measurable functions, Lebesgue integration, fundamental integral convergence theorems, functions of bounded variation, differentiation of an integral, absolutely continuous functions and L^p-spaces.		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Understand the concepts of measurable sets and Lebesgue measure; construct a non-measurable set; apply the knowledge to solve relevant exercises. CLO 2: Know about Lebesgue measurable functions and their properties; and apply the knowledge to prove Egoroff's theorem, Lusin's theorem and F. Riesz theorem. CLO 3: Understand the requirement and the concept of the Lebesgue integral (as a generalization of the Riemann integration) along its properties and demonstrate understanding of the statements and proofs of the fundamental integral convergence theorems. CLO 4: Know about the concepts of differentiation of monotonic function, functions of bounded variations, differentiation of an integral, absolutely continuous functions; apply the knowledge to prove specified theorems and study L^p-spaces.		
Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30

End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Lebesgue outer measure, elementary properties of outer measure, measurable sets and their properties, Lebesgue measure of sets of real numbers, algebra of measurable sets, Borel sets and their measurability, characterization of measurable sets in terms of open, closed, F_σ and G_δ sets, existence of a non-measurable set.	15
II	Lebesgue measurable functions and their properties, the almost everywhere concept, characteristic functions, simple functions, approximation of measurable functions by sequences of simple functions, Borel measurability of a function. Littlewood's three principles, measurable functions as nearly continuous functions. Lusin's theorem, almost uniform convergence, Egoroff's theorem, convergence in measure, F. Riesz theorem that every sequence which is convergent in measure has an almost everywhere convergent subsequence.	15
III	The Lebesgue Integral: Shortcomings of Riemann integral, Lebesgue integral of a bounded function over a set of finite measure and its properties, Lebesgue integral as a generalization of the Riemann integral, Bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions. Integral of a non-negative function, Fatou"s lemma, Monotone convergence theorem, integration of series, the general Lebesgue integral, Lebesgue convergence theorem.	15
IV	Differentiation and Integration: Differentiation of monotone functions, Vitali"s covering lemma, the four Dini derivatives, Lebesgue differentiation theorem, functions of bounded variation and their representation as difference of monotone functions. Differentiation of an integral, absolutely continuous functions and their	15

	properties, convex functions, Jensen"s inequality. L^p-spaces.	
	Total Contact Hours	60

Suggested Evaluation Methods			
Internal Assessment: 30		**End Term Examination: 70**	
➢ Theory	30	➢ Theory:	70
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1. H.L. Royden, Real Analysis (3rd Edition) Prentice-Hall of India, 2008.

Reference Books:

1. 1. G.de Barra, Measure theory and integration, New Age International, 2014.

2. P.R. Halmos, Measure Theory, Van Nostrans, Princeton, 1950.

3. I.P. Natanson, Theory of functions of a real variable, Vol. I, Frederick Ungar Publishing Co., 1961.

4. R.G. Bartle, The elements of integration, John Wiley & Sons, Inc. New York, 1966.

5. K.R. Parthsarthy, Introduction to Probability and measure, Macmillan Company of India Ltd. Delhi, 1977.

6. P.K. Jain and V.P. Gupta, Lebesgue measure and integration, New Age International (P) Ltd., Publishers, New Delhi, 1986.

CC-8 TOPOLOGY

With effect from the Session: 2024-25

Part A – Introduction	
Name of Programme	M.Sc. Mathematics
Semester	II
Name of the Course	TOPOLOGY
Course Code	M24-MAT-203
Course Type	CC
Level of the course	400-499
Pre-requisite for the course (if any)	Courses on Real Analysis up to the 299 level
Course Objectives	The main objective of this course is to introduce basic concepts of point set topology, basis and sub-basis for a topology. Further, to study continuity, homeomorphisms, open and closed maps, product and quotient topologies, separation axioms and introduce the notion of connectedness of topological spaces.
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Know about topological spaces, understand neighbourhood system of a point and its properties, interior, closure, boundary, limit points of subsets, and base and sub-base of topological spaces; apply the knowledge to solve relevant exercises. CLO 2: Learn alternate methods of defining a topology using properties of neighbourhood system, interior operator, closed sets, Kuratowski closure operator and know about first and second countable spaces, separable and Lindelof spaces. CLO 3: Know about the Tychonoff product topology and its characterization as the smallest topology such that the projection maps are continuous; connectedness and its relation with continuity. CLO 4: Have a deep understanding of T_0, T_1, T_2 spaces. Also discuss the different properties like hereditary and productive properties.

Credits	Theory	Practical	Total

	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Definition and examples of topological spaces, Comparison of topologies, Intersection and union of topologies on a set, Neighborhood's, neighborhood system of a point and its properties, interior point and interior of a set, interior as an operator and its properties, definition of a closed set as complement of an open set, limit point (accumulation point) of a set, derived set of a set, adherent point (closure point) of a set, closure of a set, closure as an operator and its properties, boundary of a set.	15
II	Dense sets, Characterization of the dense set, Base for a topology and its characterization, base for neighborhood system, sub-base for a topology. Relative (induced) topology and subspace of a topological space. Alternative methods of defining a topology in terms of neighbourhood system and Kuratowski closure operator.	15
III	First countable, second countable and separable spaces, their relationships and hereditary property, About countability of a collection of disjoint open sets in a separable and a second countable space, Lindelof theorem. Definition, examples and characterizations of continuous functions, composition of continuous functions, open and closed functions, homeomorphism, Embedding.	15

IV	Tychonoff product topology, projection maps, their continuity and openness, Characterization of product topology as the smallest topology such that the projections are continuous, T_0, T_1, T_2 spaces, productive property of T_1 and T_2 spaces. Regular and T_3 separation axioms, their characterization and basic properties i.e. hereditary and productive properties. Completely regular and Tychonoff ($T_{3\frac{1}{2}}$), spaces, their hereditary and productive properties.	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ **Theory**	**30**	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		
• Mid-Term Exam:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:
Recommended Text Books;

1. J.L. Kelley: General Topology, Springer Verlag, New York, 2012.

Reference Books:

1. J. R. Munkres, Topology, Pearson Education Asia, 2002.
2. C.W. Patty, Foundation of Topology, Jones & Bertlett, 2009.
3. Fred H. Croom, Principles of Topology, Cengage Learning, 2009.
4. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1983.
5. K. Chandrasekhara Rao, Topology, Narosa Publishing House Delhi,2009.
6. K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd, 2006.
7. Khalil Ahmad, Introduction to Topology, Narosa Publishing House, 2019.

CC-9 ORDINARY DIFFERENTIAL EQUATIONS- II

With effect from the Session: 2024-25	
Part A – Introduction	
Name of Programme	M.Sc. Mathematics
Semester	II
Name of the Course	ORDINARY DIFFERENTIAL EQUATIONS- II
Course Code	M24-MAT-204
Course Type	CC
Level of the course	400-499
Pre-requisite for the course (if any)	Courses on Differential Equation and Real Analysis up to the 299 level
Course Objectives	The objectives of this course are to study the theory of system of linear and non-linear, homogeneous and non-homogeneous differential equations with constant and/or variable coefficients, to understand the dependence of solution on initial parameters, and to understand the critical points of linear and non-linear system of differential equations and to determine types and stability of those critical points and systems" solutions. This course is an advance course on system of differential equations to give a strong foundation for doing research in the areas of differential equations and dynamical system.
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Learn about linear second-order ordinary differential equations, self-adjoint equations, superposition principle, Riccati's equation, pruffer transformation, oscillatory and non-oscillatory equations, and Abel's formula. CLO 2: Understand common zeros of solution and their linear independence, Sturm theory: Strum separation theorem, Sturm fundamental comparison theorem. CLO 3: Know about Strum-Liouville boundary value problem, orthoganality of functions and Green's function. CLO 4: Understand the Autonomous system, critical points, types of critical points. Also discuss about phase plane and path. Also discuss about the stability of critical points in homogeneous and non-homogeneous autonomous system.

Credits	Theory	Practical	Total
	4	0	4
Teaching Hours per week	4	0	4
Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Linear second-order equations: Preliminaries, Self-adjoint equation of second order, Basic facts, Superposition principle, Riccati's equation, Pruffer transformation, zero of a solution, Oscillatory and non-oscillatory equations, Abel's formula, Common zeros of solutions and their dependence.	15
II	Common zeros of solutions and their independence, Sturm theory: Strum separation theorem, Sturm fundamental comparison theorem, Elementary linear oscillations. Second-order boundary value problems (BVP): Linear problems, periodic boundary conditions, regular linear BVP, singular linear BVP, non-linear BVP.	15

III	Sturm-Liouville BVP: definitions, eigen value and eigen functions Orthogonality of eigen functions corresponding to distinct eigen values Green's function and their examples. (Relevant portions from the book „Differential Equations" by S.L. Ross)	15
IV	Nonlinear differential systems, Autonomous systems: Phase plane, Paths and Critical points, Types of critical points; Node, Center, Saddle point Spiral point, Stability of critical points, Critical points and paths of linear systems; Basic theorems and their applications. Critical points and paths of non-linear systems; Basic theorems and their applications.	
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		End Term Examination: 70	
➢ **Theory**	**30**	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	
• Seminar/presentation/assignment/quiz/class test etc.:	10		

• Mid-Term Exam:	15

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1. Earl A. Coddington and Norman Levinson, *Theory of Ordinary Differential Equations*, McGraw Hill Education, 2017.
2. Sheply L. Ross, *Differential Equations*, Wiley, 3rd Edition, 2007.
3. S.G. Deo, V. Raghavendra, Rasmita Kar, V. Lakshmikantham, *Textbook of Ordinary Differential Equations*, Tata McGraw-Hill, 2006.

Reference books;

1.P. Hartman, *Ordinary Differential Equations*, John Wiley & Sons NY, 1971.
2.G. Birkhoff and G.C. Rota, *Ordinary Differential Equations*, John Wiley & Sons, 1978.
3.G.F. Simmons, *Differential Equations*, Tata McGraw-Hill, 1993.
4.I.G. Petrovski, *Ordinary Differential Equations*, Prentice-Hall, 1966.
5.D. Somasundaram, *Ordinary Differential Equations, A first Course*, Narosa Pub., 2001.
6.Mohan C Joshi, *Ordinary Differential Equations, Modern Perspective*, Narosa PublishingHouse, 2006.

CC-10 COMPUTER PROGRAMMING WITH MATLAB

With effect from the Session: 2024-25

Part A - Introduction

Name of Programme	M.Sc. Mathematics		
Semester	II		
Name of the Course	Computer Programming With MATLAB		
Course Code	M24-MAT-205		
Course Type	CC		
Level of the course	400-499		
Pre-requisite for the course (if any)	-		
Course Objectives	This course is designed for the students to learn the computer programming. The objective of this course is to develop a skill of writing codes in MATLAB or equivalent Open Source software and using built-in tools for solving different types of mathematical problems which arise in the areas of Mathematical/Physical/Life/Social Sciences and Engineering.		
Course Learning Outcomes (CLOs) After completing this course, the learner will be able to:	CLO 1: Get familiar with the importance and working of MATLAB as computation platform through the knowledge of characters, variables, operators, functions and expressions as used for elementary operations in matrix algebra along with the editing, load/save data and compilation/execution/quitting of source programs. CLO 2: Learn the process of writing a source program in MATLAB as a programming language making use of the statements for input/output, conditional/non-sequential processing involving functions, arrays and structures. CLO 3: Learn the plotting of the curves and surfaces, which can be edited, modified, accumulated, handled, printed, exported. CLO 4: Write source programs with objects, variables, expressions, abstract functions, math functions in symbolic form and their subsequent use for the operations/ concepts/ problems in calculus, linear algebra and differential equations.		
	Theory	Practical	Total
Credits	4	0	4
Teaching Hours per week	4	0	4

Internal Assessment Marks	30	0	30
End Term Exam Marks	70	0	70
Max. Marks	100	0	100
Examination Time	3 hours		

Part B- Contents of the Course

Instructions for Paper- Setter: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory question. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Introduction: Basics of programming; Anatomy of a program; Constants; Characters; Variables; Data types; Assignments; Operators; functions; Examples of expressions; Entering long statements; Command line editing. Good programming style. Working with vectors: Defining a Vector, Accessing elements within a vector, Basic operations on vectors; Mathematical functions; Strings; String functions; Cell array; Creating cell array; Concatenation. Working with Matrices: Generating matrices; Mathematical operations and functions; Deleting rows /columns; Linear algebra; Arrays; Multivariate data; Scalar expansion; Logical subscripting; Input and output: Save/Load functions, M-files, The find function; The format function; Suppressing output; (Relevant portions from the recommended text books 1-3).	15
II	Flow Control: if and else, switch and case, for loop, while loop, continue, break, try – catch, return. Data Structures: Multidimensional arrays; Cell arrays, Characters and text; Structures, Scripts and Functions: Scripts; Functions; Types of functions; Global variables; Passing string arguments to functions; The eval function; Function handles; Function functions; Vectorization; Preallocation. Linear differential equation of order n with constant coefficients; Characteristic roots, Fundamental set. (Relevant portions from the recommended text books 1-3).	15
III	Graphics: Plotting process; Graph components; Figure tools; Arranging	15

	graphs within a figure; Selecting plot types; Plot editing mode, Using functions to edit graphs; Modifying a graph data source; Modify a graph to enhance the presentation; Printing a graph; Exporting a graph. Basic Plotting Functions: Creating a plot; Multiple data sets in one graph; Specifying line styles and colors; Plotting lines and markers; Imaginary and complex data; Adding plots to existing graph; Figure windows; Multiple plots in one figure; Controlling the axes; Axis labels and titles; Saving figures. Mesh and Surface Plots: Visualizing functions of two variables; Reading/writing images. Printing and Handle Graphics: Using the handle; Graphics object; Setting object Properties; Specifying the axes or figure, Finding the handles of existing objects. Animations: Erase mode method, Creating movies. (Relevant portions from the recommended text books 1-3).	
IV	Symbolic Math: Symbolic objects; Creating symbolic variables and expressions; The findsym Command; The default symbolic variable; Constructing real and complex variables; Creating abstract functions; Creating symbolic math functions; Creating an M-file. Calculus: Limits; Differentiation; Integration; Symbolic summation; Taylor series; Examples; Simplifications and substitutions, Variable-precision arithmetic examples. Linear Algebra: Basic algebraic operations; Linear algebraic operations; Eigenvalues; Jordan canonical form; Singular value decomposition; Eigenvalue trajectories. Solving Equations: System of algebraic equations, System of differential equations. (Relevant portions from the recommended text books 1-3).	15
	Total Contact Hours	60

Suggested Evaluation Methods

Internal Assessment: 30		**End Term Examination: 70**	
➢ **Theory**	30	➢ **Theory:**	**70**
• Class Participation:	5	Written Examination	

• Seminar/presentation/assignment/quiz/class test etc.:	10
• Mid-Term Exam:	15

Part C-Learning Resources

Recommended Books/e-resources/LMS:

Recommended Text Books;

1. *Learning MATLAB*, COPYRIGHT 1984 - 2005 by The MathWorks, Inc.
2. Amos Gilat, *MATLAB An Introduction With Applications* 5ed, Wiley, 2008.
3. Rudra Pratap, *Getting Started with MATLAB*, Oxford University Press, 2010.

Reference books;

1.C. F. Van Loan and K.-Y. D. Fan., *Insight through Computing: A Matlab Introduction to Computational Science and Engineering*, SIAM Publication, 2009.

2.T. A. Davis and K. Sigmon, *MATLAB Primer* 7th Edition, CHAPMAN & HALL/CRC, 2005.

3.B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, K. R. Coombes, J. E. Osborn, and G. J. Stuck, *A Guide to MATLAB*, Second Edition, Cambridge University Press, 2006.

4.Y.Kirani Singh, B.B. Chaudhari, *MATLAB Programming*, PHI Learning, 2007.

5.K. Ahlersten, *An Introduction to Matlab*, Bookboon.com.

6.C. Gomez, C. Bunks and J.-P. Chancelier, *Engineering and Scientific Computing with SCILAB*, Birkhäuser, 2012.

7.A. Quarteroni, F. Saleri and P. Gervasio, *Scientific Computing with MATLAB and Octave*, Springer Nature, 2014.

PC-2 PRACTICAL-2

With effect from the Session: 2024-25			
Part A - Introduction			
Name of the Programme	M.Sc. Mathematics		
Semester	II		
Name of the Course	Practical-2		
Course Code	M24-MAT-206		
Course Type	PC		
Level of the course	400-499		
Pre-requisite for the course (if any)			
Course objectives	This course aims the students to learn the practical implementations of the features of MATLAB/SCILAB/Octave which they study as a theory course M24-MAT-204 and to write codes for problem solving. Also, implementation of some problem solving techniques, based on papers M24-MAT-201 to M24-MAT-205, would be learnt.		
Course Learning Outcomes (CLO) After completing this course, the learner will be able to:	CLO 1: Solve practical problems related to theory courses undertaken in the Semester-II from application point of view. CLO 2: Know syntax of expressions, statements, data types, structures, commands and to write source code for a program in MATLAB/SCILAB/Octave. CLO 3: Edit, compile/interpret and execute the source program for desired results. CLO 4: Debug, verify/check, to obtain and store output of results.		
	Theory	Practical	Total
Credits	0	4	4
Teaching Hours per week	0	8	8
Internal Assessment Marks	0	30	30
End Term Exam Marks	0	70	70
Max. Marks	0	100	100
Examination Time	0	4 hours	
Part B- Contents of the Course			
Practicals			Contact Hours
Practical course will consist of two components Part-A and Part-B. The			120

examiner will set 5 questions at the time of practical examination asking 2 questions from the Part-A and 3 questions from the Part-B by taking course learning outcomes (CLO) into consideration. The examinee will be required to solve one problem from the Part-A and to write and execute 2 programs from the Part-B.	
Part-A Problems based on the theory courses M24-MAT-201 to M24-MAT-205 will be solved in this part and their record will be maintained in the Practical Note Book. Direct results and theorems will not be asked in this section rather exercises or numerical problems or applied problems based on the theory parts will be done, as identified or given by the teacher concerned.	30
Part-B The following practicals will be done using MATLAB/SCILAB/Octave and record of those will be maintained in the practical Note Book: 1. Create any 4 x 3 matrix A. Do the following steps: (a) Get those elements of A that are located in rows 3 to 4 and columns 2 to 3 (b) Add a fourth column to A and interchange that with the first column of A; replace the last 3 x 3 sub-matrix of A (rows 2 to 4, columns 2 to 4) by a 3 x 3 identity matrix; delete the first and third rows of A and then string out all elements of A in a row and transpose it at the end. 2. Use switch…case to calculate the income tax on a given income at the existing rates. 3. To compute the arithmetic mean, geometric mean and harmonic mean for the values {x(j), j=1,2,...,n} and the corresponding frequencies {f(j), j=1,2,...,n}. 4. Write a function file factorial to compute the factorial n! for any integer n. The input should be the number n and the output should be n!. 5. Write a function using for … loop or a while … loop to compute the sum of a geometric series $1 + r + r^2 + r^3 + \cdots + r^n$ for a given r and n. 6. Write function for the greatest common divisor (GCD) of two given positive integers and use it to find the least common multiple (LCM) of three given positive integer values and to find GCD of more than two integers. Get the result using built-in functions as well. 7. Write functions to calculate sin(x) and cos(x) as series sum of n terms. Use these functions to plot sin(x), cos(x), sin(x) +cos(x), x in $[0, 2\pi]$, for n=2, 5, 10, 20. Display the deviation of curves so plotted from those which are obtained via built-in functions. 8. Plot log(x), exp(x), sin(x) and cos(x) in a single figure. Use different colours, markers, labels and title for the graph. Also display the legend. 9. Plot a circle for given centre and a point on the boundary. Find its perimeter and area. 10. Identify the location of a given point (x, y) in terms of (a) at origin, (b) on	90 (Lab hours include instructions for writing programs and demonstration by a teacher and for running the programs on computer by students.)

x-axis or y-axis, (c) in quadrants I, II, III or IV. Verify through x-y plot.

11.	Plot (a) parametric curve using ezplot (b) polar curves using ezpolar. (c) contours using ezcontour.	
12.	For given coefficients (a, b, c, d, e), solve the equation $ax^2+by^2+2cx+2dy+e=0$ to plot the corresponding conic, viz. parabola/ hyperbola/ ellipse/ circle or else.	
13.	For given perimeter and number of sides, plot the polygon and calculate its area.	
14.	Solve a cubic equation or quartic equation with given coefficients and verify the solution through built-in function.	
15.	(a) Use polar coordinates to plot 4 circles in a plot with common centre but of different radii. (b) For 4 spheres with given centre and radii, plot their surfaces as different subplots in a figure.	
16.	Given a function $f(x) = \sin(x)$, write a MATLAB script that computes the Taylor series expansion of the function around a point x_0 up to the n terms. Evaluate the Taylor series at a set of points. Plots the original function and its Taylor series approximation on the same graph for comparison.	
17.	For a given square matrix A, find the eigen-values and eigen-vectors and check the result with the use of built-in function.	
18.	Find the inverse of a given matrix and verify the result by using built-in function.	
20.	Given matrix A of order 4x3, Plot the bar diagram corresponding to matrix A for the following cases: (a) Display four groups of three bars, different bar corresponding to each entry of row in a group (b) Display one bar for each row of the matrix. The height of each bar is the sum of the elements in the row.	
21.	Given the three vectors X, Y, Z. Represent the data Y versus X and Z versus X in one graph by using the following routines: (a) Plot ( ) (b) Scatter( ) (c) Fill ( )	
22.	For given matrices X, Y and Z, demonstrate (a) Plot3 ( ). (b) Contour( ) (c) Surf( ) (d) Surfc( )	
23.	Represent the data given by vector X by using following routines: (a) bar( ) (b) piechart( ) (c) pie3( ) (d) plot Histogram chart and Scatter chart using polar coordinates	

Suggested Evaluation Methods	
Internal Assessment: 30	**End Term Examination: 70**

➢ **Practicum**	30	➢ **Practicum**	**70**
• Class Participation:	5	Lab record, Viva-Voce, write-up and execution of the programs	
• Seminar/Demonstration/Viva-voce/Lab records etc.:	10		
• Mid-Term Examination:	15		

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Amos Gilat, *MATLAB An Introduction With Applications* 5ed, Wiley, 2008.

Reference books;

1.Rudra Pratap, *Getting Started with MATLAB*, Oxford University Press, 2010.

2.B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, K. R. Coombes, J. E. Osborn, and G. J. Stuck, *A Guide to MATLAB*, Second Edition, Cambridge University Press, 2006.