M.Sc. Mathematics

Course Structure and Syllabus

(Based on Choice Based Credit System)

2022 onwards

DEPARTMENT OF APPLIED SCIENCES (MATHEMATICAL SCIENCES)

VISION

To be among the best mathematics departments in the region and to establish a national reputation as a centre for research and teaching in mathematics. Moreover, the department will contribute to the development of students as mathematical thinkers, and to function as productive citizens.

MISSION

- To discover, mentor, and nurture mathematically inclined students, and provide them a supportive environment that fosters intellectual growth.
- To prepare our undergraduate and graduate students to develop the attitude and ability to apply mathematical methods and ideas in a wide variety of careers.
- To perform widely recognized research in focused areas of mathematical and statistical theory, methodology, and education.
- To advocate for mathematical sciences and UTEP in schools and the local community.

M.Sc. Mathematics Program

PROGRAM OBJECTIVES

Objective of the program is to catch young and talented students to motivate them to study Mathematics and to nurture them to develop their mathematical reasoning and logics. Other objectives of the program are to inspire students to pursue study in higher mathematics and grow as a skilful mathematician to cater the needs of knowledgeable society.

Duration: M.Sc. Mathematics is a postgraduate level program offered by the Department of Mathematical Sciences. This is a 2-years program, consisting of four semesters with two semesters per year.

Program Code: MSM (Master of Science in Mathematics)

Eligibility: B.A./B.Sc. or equivalent from a recognized university with Mathematics as one of the major subjects with at least 50% marks (45% in case of candidate belonging to reserved category) in aggregate.

PROGRAM OBJECTIVES: At the end of the program, the student will be able to:

1	To provide comprehensive curriculum to groom the students into qualitative scientific manpower
2	Enable students to enhance mathematical skills and understand the fundamental concepts of pure and applied mathematics.
3	To provide qualitative education through effective teaching learning processes by introducing projects, participative learning, and latest software tools.
4	To inculcate innovative skills, teamwork, ethical practices among students so as to meet societal expectations.
5	To encourage collaborative learning and application of mathematics to real life situations.
6	To inculcate the curiosity for mathematics in students and to prepare them for future research.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

PSO1	Apply the knowledge of mathematical concepts in interdisciplinary fields.
PSO2	Understand the nature of abstract mathematics and explore the concepts in further details.
PSO3	Model the real-world problems into mathematical equations and draw the inferences by finding appropriate solutions.
PSO4	Identify challenging problems in mathematics and find appropriate solutions.
PSO5	Pursue research in challenging areas of pure/applied mathematics.
PSO6	Employ confidently the knowledge of mathematical software and tools for treating the complex mathematical problems and scientific investigations.
PSO7	Continue to acquire mathematical knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematics.
PSO8	Comprehend and write effective reports and design documentation related to mathematical research and literature, make effective presentations.
PSO9	Qualify national level tests like NET/GATE etc.
PSO10	Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in society.

Scheme of the Program: First Semester **Contact Hours: 29 Hrs.**

Course Code	Course Type	Course Title	Load Allocation			Marks Distribution			Credits
			L	T	P	Internal	External	Total	
MSM-101-22	Compulsory	Algebra-I	4	1	0	40	60	100	4
MSM-102-22		Real Analysis-I	4	1	0	40	60	100	4
MSM-103-22		Complex Analysis	4	1	0	40	60	100	4
MSM-104-22		Ordinary Differential Equations and Special Functions	4	1	0	40	60	100	4
MSM-105-22		Mathematical Methods	4	1	0	40	60	100	4
MSM-106-22		Introduction to MATLAB (LAB)	0	0	4	30	20	50	2
Total			20	05	04	230	320	550	22

Scheme of the Program:Second Semester **Contact Hours: 29 Hrs.**

Course Code	Course Type	Course Title	Load Allocation			Marks Distribution			Credits
			L	T	P	Internal	External	Total	
MSM-201-22	Compulsory	Algebra-II	4	1	0	40	60	100	4
MSM-202-22		Real Analysis-II	4	1	0	40	60	100	4
MSM-203-22		Mechanics-I	4	1	0	40	60	100	4
MSM-204-22		Partial Differential Equations	4	1	0	40	60	100	4
MSM-205-22		Numerical Analysis	4	1	0	40	60	100	4
MSM-206-22		Numerical Analysis (LAB)	0	0	4	30	20	50	2
Total			20	05	04	230	320	550	22

Examination and Evaluation

Theory			
S. No.	**Evaluation criteria**	**Weightage in Marks**	**Remarks**
1	Mid term/sessional Tests	24	Internal evaluation (40 Marks) MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
2	Attendance	6	
3	Assignments	10	
4	End semester examination	60	External evaluation
5	Total	100	Marks may be rounded off to nearest integer.
Practical			
1	Evaluation of practical record/ Viva Voice/Attendance/Seminar/ Presentation	30	Internal evaluation
2	Final Practical Performance + Viva-Voce	20	External evaluation
3	Total	50	Marks may be rounded off to nearest integer.
Seminar			
1	Content	15	Internal evaluation
2	Queries	15	
3	Communication skills	10	
4	Visual effects	10	
5	Total	50	Marks may be rounded off to nearest integer.

<table>
<tr><td colspan="7">Dissertation</td></tr>
<tr><td></td><td colspan="4">Internal Assessment</td><td></td><td></td></tr>
<tr><td rowspan="2">Departmental Presentation</td><td colspan="2">Communication and presentation</td><td colspan="2">Response to queries</td><td>Maximum Marks</td><td>Evaluated by</td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td><td>50</td><td>Committee Member:
1.Head
2.Supervisor
3.One of Faculty Member</td></tr>
<tr><td rowspan="2">Dissertation</td><td>Plagiarism</td><td>Subject Matter</td><td>Usage of Language</td><td>Publication/Presentation in Conference</td><td rowspan="2">150</td><td rowspan="2"></td></tr>
<tr><td>25</td><td>70</td><td>25</td><td>30</td></tr>
<tr><td></td><td colspan="4">External Assessment</td><td></td><td></td></tr>
<tr><td rowspan="2">External Examiner</td><td colspan="4">Subject Matter</td><td rowspan="2">50</td><td rowspan="2">Committee Member:
1.Head
2.External Expert
3.Supervisor
4. Director (MC) nominee</td></tr>
<tr><td colspan="4">50</td></tr>
<tr><td rowspan="2">Viva Voce</td><td colspan="2">Communication and Presentation</td><td colspan="2">Response to queries</td><td rowspan="2">50</td><td rowspan="2"></td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td></tr>
<tr><td colspan="5">Total</td><td>300</td><td></td></tr>
</table>

Evaluation Process:

1. The subject matter evaluation can further be defined on the basis of Title, Review of literature/Motivation, Objectives, Methodology, Results and discussions, and Conclusion.
2. The usage of language and the subject matter shall be evaluated by the supervisor. Out of 300 marks, 95 marks are to be evaluated by the concerned supervisor.
3. Total 15% Plagiarism is admissible for submission of the dissertation. For (0-5)%of plagiarism, candidate should be awarded 25 marks. For >5%-10% candidate should be awarded 15 marks and for the range of > 10% to < 15%, candidate should be awarded 5 marks.

4. For publication candidate should be awarded full 30 marks and for presenting the work related to dissertation, candidate should be awarded 25 marks.

Instructions for Paper-Setter in M. Sc Mathematics

A. Scope

1. The question papers should be prepared strictly in accordance with the prescribed syllabus and pattern of question paper of the University.
2. The question paper should cover the entire syllabus with uniform distribution among each unit and Weightage of marks for each question.
3. The language of questions should be simple, direct, and documented clearly and unequivocally so that the candidates may have no difficulty in appreciating the scope and purpose of the questions. The length of the expected answer should be specified as far as possible in the question itself.
4. The distribution of marks to each question/answer should be indicated in the question paper properly.

B. Type and difficulty level of question papers

1. Questions should be framed in such a way as to test the students intelligent grasp of broad principles and understanding of the applied aspects of the subject. The Weightage of the marks as per the difficulty level of the question paper shall be as follows:

i)	Easy question	30%
ii)	Average questions	50%
iii)	Difficult questions	20%

2. The numerical content of the question paper should be up to 40%.

C. Format of question paper

1. Paper code and Paper-ID should be mentioned properly.
2. The question paper will consist of three sections: Sections-A, B and C.
3. Section-A is COMPULSORY consisting of TEN SHORT questions carrying two marks each (total 20 marks) covering the entire syllabus.
4. The Section-B consists of FOUR questions of eight marks each covering Unit I & II of syllabus (Taking two questions from each unit I & II).
5. The Section-C consists of FOUR questions of eight marks each covering Unit III & IV of syllabus (Taking two questions from each unit III & IV).
6. Sub-parts of the questions in Section B and C should be preferred for numerical/conceptual questions.
7. Attempt any five questions from Section-B and Section-C, selecting at least two questions from each of the two sections.

Question paper pattern for MST:

Roll No:		**No of pages:**
IK Gujral Punjab Technical University- Jalandhar		
Department of Mathematical Sciences		
Academic Session:		
Mid-Semester Test: I/II/III (Regular/reappear)	**Date:**	
Programme: M.Sc. Mathematics	**Semester:**	
Course Code:	**Course:**	
Maximum Marks: 24	**Time: 1 hour 30 minutes**	

❖ Note: Section A is compulsory; Attempt any two questions from Section B and one question from Section C.

Section: A		**Marks**	**Cos**
1		2	
2		2	
3		2	
4		2	
Section: B			
5		4	
6		4	
7		4	
Section: C			
8		8	
9		8	

Details of Course Objectives

CO1	
CO2	
CO3	
CO4	
CO5	

SEMESTER-I

MSM-101-22	**Algebra-I**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Discrete Structures			
Course Objectives: This course is designed to give students a foundation for all future mathematics courses. The fundamentals of algebraic problem-solving are explained. Students will explore foundations of Algebraic structures, Groups, Rings, Ideals, Fields, Homomorphisms, etc. The course also fulfills the objective to make students aware of the applicability of abstract mathematics in real world problems.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Apply the knowledge of Algebra to attain a good mathematical maturity and enables to build mathematical thinking and skill.
CO2	Utilize the class equation and Sylow theorems to solve different related problems.
CO3	Identify and analyze different types of algebraic structures such as Solvable groups, Simple groups, Alternate groups to understand and use the fundamental results in Algebra.
CO4	Design, analyze and implement the concepts of homomorphism and isomorphism between groups and rings for solving different types of problems, for example, Isomorphism theorems, quotient groups, conjugacy etc.
CO5	Create, select, and apply appropriate algebraic structures such as finitely generated abelian groups, Ideals, Fields to explore the existing results.
CO6	Identify the challenging problems in modern mathematics and find their appropriate solutions.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	√	√	-	√	-	√	√
CO2	√	√	-	√	-	-	√	-	√	√
CO3	√	√	-	√	√	-	√	-	√	√
CO4	√	√	-	√	√	-	√	-	√	√
CO5	√	√	-	√	-	-	√	-	√	√
CO6	√	√	-	√	-	-	√	-	√	√

Course Title: Algebra-I
Course Code: MSM-101-22

UNIT-I

Groups, Subgroups & Homomorphisms: Groups, homomorphisms, Subgroups and Cosets, Cyclic groups, Permutation groups, Normal subgroups and quotient groups, Isomorphism theorems, Automorphisms, Symmetric groups, Conjugacy. [Ref 2: Unit 1]

UNIT-II

Solvability & Simplicity: Normal series, Derived Series, Composition Series, Solvable Groups, Simple groups and their examples, Alternating group A_n, Simplicity of A_n. [Ref 2: Unit 1]

UNIT-III

Finite Abelian Groups: Direct products, Finite Abelian Groups, Fundamental Theorem on Finitely generated Abelian Groups, Invariants of a finite abelian groups, Sylow's Theorems and their applications, Groups of order p^2, pq. [Ref 2: Unit 1]

UNIT-IV

Rings & Ideals: Ring, Subring, Ideals, Homomorphism and Algebra of Ideals, Maximal and prime ideals, Ideals in quotient rings, Nilpotent and nil ideals. [Ref 2: Unit 2]

RECOMMENDED BOOKS:

1. Bhattacharya, P. B., Jain, S.K. and Nagpaul, S.R., *Basic Abstract Algebra*, *2nd Edition.* U.K.: Cambridge University Press, 2004.
2. Dummit, David. S., and Foote, Richard M., *Abstract Algebra, 3rd Edition*. New Delhi: Wiley, 2011.
3. Herstein, I.N., *Topics in Algebra, 2nd Edition*. New Delhi: Wiley, 2006.
4. Singh, Surjeet, and Zameeruddin, Q., *Modern Algebra, 7th Edition*. New Delhi: Vikas Publishing House, 1993.
5. Artin, M., *Algebra, 2nd Edition*. Pearson Publications, 2010.

MSM-102-22	**Real Analysis-I**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Basic Calculus			
Course Objectives: This course is designed to provide a deeper and rigorous understanding of fundamental concepts viz. metric spaces, continuous functions, sequences, series: power series and the Riemann-Stieltjes integral etc. The focus of this course will be on theoretical foundation of the above said concepts and it will cultivate the rigorous mathematical logics and skills in the students.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Apply the knowledge of concepts of real analysis to study theoretical development of different mathematical techniques and their applications.
CO2	Understand the nature of abstract mathematics and explore the concepts in further details.
CO3	Identify challenging problems in real variable theory and find their appropriate solutions.
CO4	Deal with axiomatic structure of metric spaces and generalize the concepts of sequences and continuous functions in metric spaces.
CO5	Use theory of Riemann-Stieltjes integral which is a modification of Riemann theory of integration.
CO6	Extend their knowledge of real variable theory for further exploration of the subject at more advanced level.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	-	-	-	√	-	√	√
CO2	-	√	-	-	-	-	√	-	√	√
CO3	-	-	-	√	-	-	√	-	√	√
CO4	-	√	-	-	-	-	√	-	√	√
CO5	√	-	-	-	-	-	√	-	√	√
CO6	-	-	-	-	√	-	√	-	√	√

Course Title: Real Analysis-I
Course Code: MSM-102-22

UNIT-I

Finite, Countable and Uncountable sets, Metric spaces, Open sets, closed sets, Compact sets, Perfect sets, Connected sets.

UNIT-II

Sequences, Convergent sequences, Subsequences, Cauchy sequences, Complete metric spaces. Cantor's intersection theorem, power series, absolute convergence.

UNIT-III

Continuity: Limits of functions, Continuous functions, Continuity and Compactness, Continuity and Connectedness, Discontinuities, Monotonic functions, Uniform continuity.

UNIT-IV

The Riemann-Stieltjes integral: Definition and existence of the Riemann-Stieltjes integral, Condition of integrability, The Riemann-Stieltjes integral as a limit of sum, Properties of the integral, Relation between Riemann integral and Riemann-Stieltjes integral, First and second mean value theorems of Riemann-Stieltjes integral.

RECOMMENDED BOOKS:

1. Rudin, W., *Principles of Mathematical Analysis, 3rd Edition*. New Delhi: McGraw-Hill Inc., 2013.
2. Royden, H.L. and Fitzpatrick, P.M., *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.
3. Carothers, N. L., *Real Analysis*, Cambridge University Press, 2000.
4. Apostol, T.M., *Mathematical Analysis –A modern approach to Advanced Calculus*. New Delhi: Narosa Publishing House, 1957.
5. Abbott, S., *Understanding Analysis, 2nd Edition.* Springer, 2016.
6. Malik S. C., Arora Savita, *Mathematical Analysis, 5th Edition,* New Age International Publishers, 2017.

MSM-103-22	Complex Analysis	L-4, T-1, P-0	4 Credits

Pre-requisite: Calculus of several variables and complex number system.

Course Objectives: The objective of this course is to introduce and develop a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions and to make students equipped with the understanding of the fundamental concepts of complex variable theory. In particular, to enable students to acquire skill of contour integration to evaluate complicated real integrals via residue calculus.

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

CO1	Know the fundamental concepts of complex analysis.
CO2	Evaluate complex integrals and apply Cauchy integral theorem and formula.
CO3	Evaluate limits and checking the continuity of complex function & apply the concept of analyticity and the Cauchy-Riemann equations.
CO4	Solve the problems using complex analysis techniques applied to different situations in engineering and other mathematical contexts.
CO5	Establish the capacity for mathematical reasoning through analysing, proving and explaining concepts from complex analysis
CO6	Extend their knowledge to pursue research in this field.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	-	√	-	√	-	√	√
CO2	√	√	-	√	√	-	√	-	√	√
CO3	√	√	-	√	√	-	√	-	√	√
CO4	√	√	√	√	√	-	√	-	√	√
CO5	√	√	√	√	√	-	√	-	√	√
CO6	√	√	√	√	√	-	√	-	√	√

Course Title: Complex Analysis

Course Code: MSM-103-22

UNIT-I

Function of complex variable, continuity and differentiability, Analytic functions, Cauchy Riemann equation (Cartesian and polar form). Harmonic functions, Harmonic conjugate, Construction of analytic functions. Stereographic projection and the spherical representation of the extended complex plane.

Unit-II

Complex line integral, Cauchy-Goursat theorem, independence of path; Cauchy's integral formulas and their consequences, Cauchy inequality, Liouville's theorem, Fundamental theorem of algebra, Morera's theorem.

Unit-III

Power series: Zeros and singularities of complex functions, classification of singularities: removable singularity, poles, essential singularities, Residue at a pole and at infinity, Circle of convergence, radius of convergence. Taylor's series and Taylor's theorem, Laurent'z series and Laurent theorem, Cauchy's Residue theorem and its applications in evaluation of real integrals: integration around unit circle, integration over semi-circular contours (with and without real poles), integration around rectangular contours.

Unit-IV

Conformal transformations, Bilinear transformations, Critical points, Fixed points, Problems on cross-ratio and bilinear transformation.

RECOMMENDED BOOKS:

1. Ahlfors, L.V., *Complex Analysis, 2nd Edition*. McGraw-Hill International Student Edition, 1990.
2. Kumar, R.R., Complex Analysis, Pearson Education, 2015.
3. Churchill, R. and Brown, J.W., *Complex Variables and Applications*, *6th Edition*. New- York: McGraw-Hill, 1996.

MSM-104-22	**Ordinary Differential Equations and Special Functions**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Differential Calculus, Integral Calculus and some introduction to linear algebra.			
Course Objectives: The Objective of this course is to introduce ordinary differential equations and fundamental theorems for existence and uniqueness. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations appearing in various fields of science and technology.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Understand ordinary differential equations of various types, their solutions, and fundamental concepts about their existence.
CO2	Understand the concept and applications of eigen value problems.
CO3	Understand differential equations of Strum Liouville type.
CO4	Apply various power series methods to obtain series solutions of differential equations.
CO5	Discuss various kinds of special functions in detail, their properties, and relations.
CO6	Solve problems of ordinary differential equations arising in various fields.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	√	-	√	√
CO2	√	-	√	√	√	-	√	-	√	√
CO3	√	-	√	√	√	-	√	-	√	√
CO4	√	-	√	√	√	-	√	-	√	√
CO5	√	-	√	√	√	-	√	-	√	√
CO6	√	-	√	√	√	-	√	-	√	√

Course Title: Ordinary Differential Equations and Special Functions

Course Code: MSM-104-22

UNIT-I

Review of linear differential equations with constant & variable coefficients, Fundamental existence and uniqueness theorem for system and higher order equations (Picard's and Piano theorems), System of linear differential equations, an operator method for linear system with constant coefficients, Phase plane method.

UNIT-II

Homogeneous linear system with constant coefficients, Eigenvalues and eigen functions, orthogonality of eigen functions, Complex eigenvalues, repeated eigenvalues, Ordinary differential equations of the Sturm-Liouville problems, Expansion theorem, Extrema properties of the eigen values of linear differential operators, Formulation of the eigen value problem of a differential operator as a problem of integral equation, Linear homogeneous boundary value problems

UNIT-III

Power series solution of differential equations: about an ordinary point, solution about regular singular points, the method of Frobenius, Bessel equation and Bessel functions, Recurrence relations and orthogonal properties., Series expansion of Bessel Coefficients, Integral expression, Integral involving Bessel functions, Modified Bessel function, Ber and Bei functions, Asymptotic expansion of Bessel Functions, Legendre's differential equations, Legendre Polynomials , Rodrigue's formula, Recurrence relations and orthogonal properties.

UNIT-IV

The Hermite polynomials, Chebyshev's polynomial, Laugrre's polynomial: Recurrence relations, generating functions and orthogonal properties.

RECOMMENDED BOOKS:

1. Ross, S.L., *Differential Equations, 3rd Edition.* John Wiley & Sons, 2004.
2. Boyce, W.E. and Diprima, R.C., *Elementary Differential Equations and Boundary Value problems, 4th Edition*. John Wiley and Sons, 1986.
3. Sneddon, I.N., *Special Functions of Mathematical Physics and Chemistry.* Edinburg: Oliver & Boyd, 1956.
4. Bell, W.W., *Special Functions for Scientists and Engineers.* Dover, 1986.

MSM-105-22	**Mathematical Methods**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Basic Calculus and Linear Algebra

Course Objectives: The objective of the course is to acquaint the students with the knowledge of mathematical techniques frequently applied in various branches of engineering and sciences. Also, one of the objectives of this course is to equip the students with the mathematical background required for the development of such techniques.

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

CO1	Understand the theory and applications of integral transforms.
CO2	Explain how integral transforms can be used to solve a variety of differential equations.
CO3	Solve integro-differential equations of Fredholm and Volterra type.
CO4	Understand the properties of various kinds of integral equations.
CO5	Develop their attitude towards problem solving.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	√	-	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

Course Title: Mathematical Methods
Course Code: MSM-105-22

UNIT I

Laplace Transforms: Laplace Transform, Properties of Laplace Transform, Inverse Laplace Transform, Convolution theorem, Laplace transform of periodic functions, unit step function and impulsive function, Application of Laplace Transform in solving ordinary and partial differential equations and Simultaneous linear equations.

UNIT II

Fourier Transforms: Fourier transform, properties of Fourier transform, inversion formula, convolution, Parseval's equality, Fourier transform of generalized functions, application of Fourier transforms in solving heat, wave and Laplace equation. Fast Fourier transform.

UNIT III

Integral Equations: Relations between differential and integral equations, Integral equations of Fredholm and Volterra type, solution by successive substitution and successive approximation, integral equations with degenerate kernels.

UNIT IV

Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems, integral equations with symmetric kernel, Solutions with separable kernels, Characteristic numbers, Resolvent kernel, Eigen values and Eigen functions of integral equations and their simple properties.

Text and Reference Books:

1. Sneddon, I.N., *The Use of Integral Transforms*. McGraw Hill, 1985.
2. Goldberg, R.R., *Fourier Transforms.* Cambridge University Press, 1970.
3. Smith, M.G., *Laplace Transform Theory*. Van Nostrand Inc., 2000.
4. Elsegolc, L., *Calculus of Variation*. Dover Publications, 2010.
5. Kenwal, R.P., *Linear Integral Equation; Theory and Techniques*. Academic Press, 1971.
6. Hildebrand, F.B., *Methods of Applied Mathematics* ***(Latest Reprint)***. Dover Publications.
7. Pal, S. and Bhunia, S.C., *Engineering Mathematics*. Oxford University Press, 2015.

MSM-106-22	**Introduction to MATLAB (LAB)**	**L-0, T-0, P-4**	**2 Credits**

Pre-requisite: Basic knowledge of computer

Course Objectives: This course is designed to introduce a powerful language MATLAB for technical computing. The main focus of the course will be on introduction to basic concepts of MATLAB and their applications using simple examples. This course will also develop programming skills for solving real world problems more efficiently and accurately

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

CO1	Apply the knowledge of mathematical software viz. MATLAB to solve real world problems efficiently.
CO2	Utilize the symbolic tools of MATLAB for handling different mathematical problems for example, solution of equations, differentiation, and integration etc.
CO3	Design and analyze their own computer codes of mathematical methods.
CO4	Understand and modify existing codes in scientific computing based on the use of different loops and conditional structures.
CO5	Use MATLAB software effectively for plotting in 2D and 3D.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	-	-	√	-	-		√
CO2	√	-	-	-	-	√	-	-		√
CO3	√	-	-	-	-	√	-	-		√
CO4	-	-	-	-	-	√	-	-		√
CO5	√	-	-	-	-	√	-	-		√

Course Title: Introduction to MATLAB (LAB)
Course Code: MSM-106-22

UNIT-I

The MATLAB environment, scalars, variables, arrays, mathematical operations with arrays, built-in and user defined functions, script file, input to a script file, output commands: disp and fprintf, function files, comparison between script file and function file.

Plotting: Two-dimensional plots and three-dimensional plots.

UNIT-II

Programming: Relational and logical operators, Conditional statements: if-end structure; if-else-end structure; if-elseif-else-end structure, loops: for-end loop and while-end loop, Nested loops and nested conditional statements, the break and continue command.

Symbolic math: symbolic objects and symbolic expressions; commands: collect, expand, factor, simplify, simple, solve, diff and int.

Text and Reference Books:

1. Higham, D.J. and Higham, N.J., MATLAB Guide, 2nd Edition. Society for Industrial and Applied Mathematics (SIAM), 2005.
2. Gilat, A., MATLAB: An Introduction with Applications, 5th Edition. John Wiley & Sons, 2014.

SEMESTER-II

MSM-201-22	**Algebra-II**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Groups, rings, ideals and other concepts studied in Algebra-I course.

Course Objectives: This course is designed to introduce the students to advanced ideas such as Polynomial rings, Field theory, Algebraic closures, splitting fields and Galois theory. It helps the students to learn about Eisenstein's irreducibility criterion which is quite helpful in the study of solvability of a polynomial. It makes the students to understand about the applications of Galois theory in other branches of mathematics.

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

CO1	Apply the knowledge of concepts of Polynomial rings, Euclidean Domain, UFD etc.
CO2	Understand the nature of abstract mathematics and explore the concepts in further details
CO3	Utilize the concepts of Einstein irreducibility criteria to check the factorization of polynomials, extension of fields etc.
CO4	Recognize the need of concept of fundamental theorem of algebra from a practical viewpoint.
CO5	Understand Galios extensions from theoretical point of view and apply its tools in different fields of applications.
CO6	Extend their knowledge of Homomorphisms, automorphisms and fixed fields by selecting and applying its tools for further research in this and other related areas.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	√	√	-	-	-	√	√
CO2	-	√	-	√	√	-	-	-	√	√
CO3	√	-	-	√	√	-	-	-	√	√
CO4	-	√	-	√	√	-	-	-	√	√
CO5	-	√	-	√	√	-	-	-	√	√
CO6	-	-	-	√	√	-	-	-	√	√

Course Title: Algebra-II

Course Code: MSM-201-22

UNIT-I

Polynomial rings, factorization Domain and divisibility, Principal Ideal Domain (PID), Euclidean Domain (ED), factorization of polynomials in one variable over a field. Unique factorization domains, unique factorization in R[x], where R is a Unique Factorization Domain. Euclidean and Principal ideal domain. [Ref 2: Unit 2]

UNIT-II

Gauss Lemma, irreducible polynomials and Eisenstein's Irreducibility Criterion, Fields, Adjunction of roots, Algebraic extensions of field. [Ref 2: Unit 2,4]

UNIT-III

Algebraically closed fields, Splitting fields, normal extensions, finite fields, separable extensions. [Ref 2: Unit 4]

UNIT-IV

Automorphism of groups and fixed fields, Galois extensions. The fundamental theorem of Galois Theory, Fundamental theorem of algebra. [Ref 2: Unit 4]

RECOMMENDED BOOKS:

1. Bhattacharya, P.B., Jain, S.K. and Nagpaul, S.R., *Basic Abstract Algebra*, *2nd Edition.* U. K.: Cambridge University Press, 2004.
2. Dummit, David. S., and Foote, Richard M., *Abstract Algebra, 3rd Edition*. New Delhi: Wiley, 2011.
3. Herstein, I.N., *Topics in Algebra, 2nd Edition*. New Delhi: Wiley, 2006.
4. Singh, Surjeet, and Q. Zameeruddin. *Modern Algebra, 7th Edition*. New Delhi: Vikas Publishing House, 1993.
5. Ash, R., *Abstract Algebra: The Basic Graduate Year*, Dover Publications Inc, 2006.

MSM-202-22	**Real Analysis-II**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Calculus of several variables and Real Analysis-I

Course Objectives: This course is designed to provide theoretical foundations of concepts of mathematical analysis, viz. sequence and series of functions, measure theory and integration that have many important applications in different branches of pure and applied mathematics. Further, this course will also develop rigorous understanding of the above said concepts.

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

CO1	Apply the knowledge of concepts of real analysis to study theoretical development of different mathematical concepts and their applications.
CO2	Understand the nature of abstract mathematics and explore the concepts in further details.
CO3	Apply the concepts of real analysis in solving and analyzing real world problems.
CO4	Recognize and elaborate the need of concept of measure from a practical viewpoint.
CO5	Understand measure theory and integration from theoretical point of view and apply its tools in different fields of applications.
CO6	Extend their knowledge of Lebesgue theory of integration by selecting and applying its tools for further research in this and other related areas

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	√	√	-	-	-	√	√
CO2	-	√	-	√	√	-	-	-	√	√
CO3	√	-	-	√	√	-	-	-	√	√
CO4	-	√	-	√	√	-	-	-	√	√
CO5	-	√	-	√	√	-	-	-	√	√
CO6	-	-	-	√	√	-	-	-	√	√

Course Title: Real Analysis-II

Course Code: MSM-202-22

UNIT-I

Sequences and series of functions, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, Weierstrass approximation theorem.

UNIT-II

Lebesgue Measure: Introduction, Lebesgue outer measure, Measurable sets and Lebesgue measure, non-measurable set, Measurable functions, Borel and Lebesgue measurability, Littlewood's three principles.

UNIT-III

Lebesgue Integral: The Lebesgue integral of a bounded function over a set of finite measure, the Comparison of Riemann and Lebesgue integral, the integral of a nonnegative function, The general Lebesgue integral, Convergence in measure.

UNIT-IV

Differentiation and Integration: The Four derivatives, Differentiation of monotone functions, differentiation of an integral. Absolute continuity.

RECOMMENDED BOOKS:

1. Royden, H.L. and Fitzpatrick, P.M., *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.
2. Barra, G. de., *Measure Theory and Integration*, New Delhi: Woodhead Publishing, 2011.
3. Rudin, W., *Principles of Mathematical Analysis, 3rd Edition*. New Delhi: McGraw-Hill Inc., 2013.
4. Carothers, N. L., *Real Analysis*, Cambridge University Press, 2000.
5. Apostol, T.M., *Mathematical Analysis –A modern approach to Advanced Calculus*. New Delhi: Narosa Publishing House, 1957.
6. Malik S. C., Arora Savita, *Mathematical Analysis, 5th Edition,* New Age International Publishers, 2017.

MSM-203-22	Mechanics-I	L-4, T-1, P-0	4 Credits

Pre-requisite: Basic Mechanics and Calculus of several variables

Course Objectives: To demonstrate knowledge of functional and extremum path and the application of the knowledge in solving some fundamental problems. To demonstrate the knowledge and understanding of the fundamental concepts in the dynamics of system of particles and Lagrangian and Hamiltonian formulation of mechanics. To represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulation of classical mechanics.

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

CO1	Understand the concept of functional and determine stationary paths of a functional to deduce the differential equation for stationary paths.
CO2	Use Euler-Lagrange equation to find stationary paths and its applications in some classical fundamental problems.
CO3	Define and understand basic mechanical concepts related to discrete and continuous mechanical systems.
CO4	describe and understand the motion of a mechanical system using Lagrange-Hamilton formalism.
CO5	Connect concepts and mathematical rigor to enhance understanding.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	√	-	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	√	-	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

Course Title: Mechanics-I

Course Code: MSM-203-22

UNIT-I

Functional and its properties, Variation of a functional, Motivating problems: Brachistochrone, isoperimetric, Geodesics. Fundamental lemma of calculus of variation, Euler's equation for one dependent function of one and several variables. Generalization to *n* dependent functions and dependence on several derivatives. Invariance of Euler's equation, Moving end points problem, extremum under constraints.

UNIT-II

Constraints, generalized coordinates, Generalized velocity, Generalized force, Generalized potential, D'Alembert principle, Lagrange's equation of first kind and second kind, uniqueness of solution, Energy equation for conservative field. Examples based on solving Lagrange's equation.

UNIT-III

Legendre transformation, Hamilton canonical equation, cyclic coordinates, Routhian procedure, Poisson bracket, Poisson's identity, Jacobi-Poisson theorem, Hamilton's principle, Principle of Least action.

UNIT-IV

Canonical transformations, Hamilton-Jacobi equation. Method of Separation of variables, Lagrange's bracket, Hamilton's equations in Poisson bracket, Canonical character of transformation through Poisson bracket. Invariance of Lagrange's bracket and Poisson's bracket.

RECOMMENDED BOOKS:

1. Elsegolc, L.D., *Calculus of Variation*, Dover Publication, 2007.
2. Gantmacher, F., *Lectures in Analytic Mechanics,* Moscow: Mir Publisher, 1975.
3. Goldstien, H., Poole, C. and Safco, J.L., *Classical Mechanics, 3rd Edition*. Addison Wesely, 2002.
4. Landau, L.D. and Lipshitz, E.M., *Mechanics,* Oxford: Pergamon Press, 1976.
5. Marsden, J.E., *Lectures on Mechanics*, Cambridge University Press, 1992.
6. Biswas, S. N., *Classical Mechanics*, Books and Applied (P) Ltd., 1999.

MSM-204-22	**Partial Differential Equations**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Calculus of several variables and ODE

Course Objectives: The Objective of this course is to introduce first and higher order partial differential equations and their classification. This course explains various analytic methods for computing the solutions of various partial differential equations. It also explains various applications of partial differential equations in real physical phenomenon like wave equation of string, diffusion equations and heat flow equations to students.

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

CO1	Understand partial differential equations of first order (linear and nonlinear), second and higher order.
CO2	Apply various analytic methods for computing solutions of various PDEs.
CO3	Determine integral surfaces passing through a curve, characteristic curves of second order PDE and compatible systems.
CO4	Understand the formation and solution of some significant PDEs like wave equation, heat equation and Laplace equation.
CO5	Apply the knowledge of PDEs and their solutions to understand physical phenomena.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	-	√	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

Course Title: Partial Differential Equations

Course Code: MSM-204-22

UNIT-I

First Order PDE: Partial differential equations; its order and degree; origin of first order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution.

UNIT-II

Second Order PDE: Origin of second order PDE; linear second order PDE with constant and variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order.

UNIT-III

Separation of Variable Method and Derivation of Heat, wave and Laplace equations: Derivation of one-dimensional wave equation, Derivation of two-dimensional wave equation, Laplace's equation, Laplace's equation in plane polar coordinates, Laplace's equation in cylindrical coordinates, Laplace's equation in spherical coordinates, Derivation of one-dimensional heat equation.

UNIT-IV

Boundary value problems using separation of Variable Method: Boundary value problems in cartesian co-ordinates on Heat equation, wave equation and Laplace equation (1-D, 2-D and 3-D), Boundary value problems in polar co-ordinates, Boundary value problems in cylindrical co-ordinates, Boundary value problems in spherical co-ordinates.

RECOMMENDED BOOKS:

1. Sneddon, I.N., *Elements of Partial Differential Equation, 3rd Edition.* McGraw Hill Book Company, 1998.
2. Copson, E.T., *Partial Differential Equations, 2nd Edition.* Cambridge University Press, 1995.
3. Strauss, W.A., *Partial Differential Equations: An Introduction*, *2nd Edition*. 2007.
4. Sharma, J.N. and Singh, K., *Partial differential equations for engineers and scientists*, *2nd Edition*. New Delhi: Narosa Publication House, 2009.

MSM-205-22	**Numerical Analysis**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Basic Calculus, analysis and linear algebra			
Course Objectives: This course is designed to introduce the basic concepts of Numerical Mathematics to solve the problems arising in various fields of application, for example in science, engineering and economics etc. that do not possess analytical solutions or difficult to deal with analytically. This course addresses development, analysis and application of different numerical methods to solve the problems, viz. system of linear & nonlinear equations, numerical initial and boundary value problems of ordinary differential equations etc.			
Course Outcomes: At the end of the course, the students will be able to			
CO1	Identity and analyze different types of errors encountered in numerical computing.		
CO2	Apply the knowledge of Numerical Mathematics to solve problems efficiently arising in science, engineering, and economics etc.		
CO3	Utilize the tools of the Numerical Mathematics in order to formulate the real-world problems from the viewpoint of numerical mathematics.		
CO4	Design, analyze and implement of numerical methods for solving different types of problems, viz. initial and boundary value problems of ordinary differential equations etc.		
CO5	Create, select, and apply appropriate numerical techniques with the understanding of their limitations so that any possible modification in these techniques could be carried out in further research.		
CO6	Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently.		

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	-	-	√	-	-	-	-	√	√
CO2	√	-	-	-	-	-	-	-	√	√
CO3	√	-	-	-	-	-	-	-	√	√
CO4	√	-	-	-	-	-	-	-	√	√
CO5	√	√	-	-	-	√	-	-	√	√
CO6	-	-	-	√	-	-	-	-	√	√

Course Title: Numerical Analysis
Course Code: MSM-205-22

UNIT-I

Numerical computation and Error analysis: Numbers and their accuracy, Floating point arithmetic, Errors in numbers, Error estimation, General error formulae, Error propagation in computation. Inverse problem of error analysis and Numerical instability. Algebraic and transcendental equations: Bisection method, Iteration method, Regula-Falsi method, Secant method, Newton-Raphson's method. Convergence of these methods. Solution of system of nonlinear equations: Newton-Raphson's method.

UNIT-II

System of linear algebraic equations: Gauss elimination method without pivoting and with pivoting, Gauss-Jordon method, LU-factorization method, Jacobi and Gauss-Seidal methods, Convergence of iteration methods, Round-off errors and refinement, ill-conditioning, Inverse of matrices: Partition method. Eigen values and eigen vectors: Rayleigh Power method, Given's method.

UNIT-III

Interpolation: Finite differences, Newton's interpolation formulae, Gauss, Stirling's and Bessel's formulae, Lagrange's, Hermite's and Newton's divided difference formulae. Numerical differentiation and integration: differentiation at tabulated and non-tabulated points, Maximum and minimum values of tabulated function, Newton-Cotes Formulae-Trapezoidal, Simpson's, Boole's and Weddle' rules of integration with errors, Romberg integration. Double integration: Trapezoidal method and Simpson's method.

UNIT-IV

Ordinary differential equations: Taylor series and Picard's methods, Euler's and modified Euler methods, Runge-Kutta methods, Predictor-Corrector methods: Adams-Bashforth's and Milne's methods. Error analysis and accuracy of these methods. Solution of simultaneous and higher order equations, Boundary value problems of Ordinary differential equations: Finite difference methods.

RECOMMENDED BOOKS:

1. Sharma, J.N., *Numerical Methods for Engineers and Scientists, 2nd Edition*. Narosa Publ. House New Delhi/Alpha Science International Ltd., Oxford UK, 2007, Reprint 2010.
2. Jain, M.K., Iyengar, S.R.K. and Jain, R.K., *Numerical Methods for Scientific and Engineering Computation, 5th Edition. New Age International Publ.* New Delhi, 2010
3. Bradie, B., *A Friendly Introduction to Numerical Analysis*. Pearson Prentice Hall, 2006.
4. Atkinson, K.E., *Introduction to Numerical Analysis, 2nd Edition*. John Wiley, 1989.
5. Scarborough, J.B., *Numerical Mathematical Analysis.* Oxford & IBH Publishing Co., 2001.

MSM-206-22	**Numerical Analysis (LAB)**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisite: Basic knowledge of Computer and MATLAB Programming			
Course Objectives: This course is designed to provide understanding of implementation of basic numerical methods for solving different problems viz. nonlinear equations, system of linear equations, interpolation and extrapolation, numerical differentiation and integration, numerical initial and boundary value problems of ordinary differential equations etc. Further, this course will develop programming skills in the students to write and implement their own computer programs for solving problems arising in science, engineering and economics.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Apply their knowledge of computer programming to develop and implement their own computer codes of numerical methods for solving different types of complex problems viz. nonlinear equations, system of linear equations, interpolation and extrapolation, numerical differentiation and integration, numerical initial and boundary value problems of ordinary differential equations etc.
CO2	Understand different implementation modes of a numerical method to solve a given problem efficiently.
CO3	Analyze and modify computer codes available in the scientific literature.
CO4	Utilize the symbolic tools of MATLAB independently and in their computer codes for solving a given problem.
CO5	Develop, select and apply numerical methods as a computer code with the understanding of their limitations so that they can be implemented in order to get acceptable results.
CO6	Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently using computer codes.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	-	-	-	-	-	√	√
CO2	-	√	-	-	-	-	-	-	√	√
CO3	√	√	-	-	-	-	-	-	√	√
CO4	√	-	-	-	-	-	-	-	√	√
CO5	√	√	-	-	-	-	-	-	√	√
CO6	-	-	-	√	-	-	-	-	√	√

Course Title: Numerical Analysis (LAB)

Course Code: MSM-206-22

The following programs of following methods are to be practiced:

1. To find a real root of an algebraic/ transcendental equation by using Bisection method.
2. To find a real root of an algebraic/ transcendental equation by using Regula-Falsi method.
3. To find a real root of an algebraic/ transcendental equation by using Newton-Raphson method.
4. To find a real root of an algebraic/ transcendental equation by using Iteration method.
5. Implementation of Gauss- Elimination method to solve a system of linear algebraic equations.
6. Implementation of Jacobi's method to solve a system of linear algebraic equations.
7. Implementation of Gauss-Seidel method to solve a system of linear algebraic equations.
8. To find differential coefficients of 1st and 2nd orders using interpolation formulae.
9. To evaluate definite integrals by using Newton - Cotes integral formulae.
10. To evaluate double integrals by using Trapezoidal and Simpson method.
11. To compute the solution of ordinary differential equations with Taylor's series method.
12. To compute the solution of ordinary differential equations by using Euler's method.
13. To compute the solution of ordinary differential equations by using Runge -Kutta methods.
14. To compute the solution of ordinary differential equations by using Milne-Simpson method.
15. To compute the solution of Boundary value problems of Ordinary Differential Equations by using Finite Difference method.

RECOMMENDED BOOKS:

1. Fausett, L.V., *Applied Numerical Analysis using MATLAB, 2nd Edition.* Pearson Prentice Hall, 2007.
2. Mathews, J.H. and Fink, K.D., *Numerical Methods using MATLAB, 4th Edition.* Pearson Prentice Hall, 2004.
3. Conte, S.D. and Boor, C.D., *Numerical Analysis*. New York: McGraw Hill, 1990.