Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati (Autonomous)

Credit Distribution Structure for (M.Sc. Mathematics) Part-I (2023 Pattern)

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Level</th><th rowspan="2">Sem.</th><th colspan="2">Major</th><th rowspan="2">Research Methodology (RM)</th><th rowspan="2">OJT/ FP</th><th rowspan="2">RP</th><th rowspan="2">Cum. Cr.</th></tr>
<tr><th>Mandatory</th><th>Electives</th></tr>
<tr><td rowspan="10">I</td><td rowspan="10">6.0</td><td rowspan="4">Sem-I</td><td>MAT-501-MJM: Measure Theory and Integration(Credit 04)</td><td rowspan="4">MAT-511-MJE (A): Numerical Analysis (Credit04)
OR
MAT-511-MJE (B): Group Theory(Credit 04)</td><td rowspan="4">MAT-521-RM: Research Methodology in Mathematics (Credit 04)</td><td rowspan="4">--</td><td rowspan="4">--</td><td rowspan="4">20</td></tr>
<tr><td>MAT-502-MJM: Advanced Calculus (Credit 04)</td></tr>
<tr><td>MAT-503-MJM: Practical in Ordinary Differential Equations(Credit 02)</td></tr>
<tr><td>MAT-504-MJM: Programming in C (Credit 02)</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td rowspan="4">Sem- II</td><td>MAT-551-MJM: Complex Analysis (Credit 04)</td><td rowspan="4">MAT-561-MJE(A): Number Theory(Credit04)
OR
MAT-561-MJE(B): Rings and Modules(Credit04)</td><td rowspan="4">--</td><td rowspan="4">MAT-581-OJT/FP Credit 04</td><td rowspan="4">--</td><td rowspan="4">20</td></tr>
<tr><td>MAT-552-MJM:Topology (Credit 04)</td></tr>
<tr><td>MAT-553-MJM: Practical in Partial Differential Equations (Credit 02)</td></tr>
<tr><td>MAT-554-MJM: Programming in C++ (Credit 02)</td></tr>
<tr><td colspan="3">Cum. Cr.</td><td>24</td><td>8</td><td>4</td><td>4</td><td>--</td><td>40</td></tr>
</table>

*** 1 credit = 15 Hr.**

Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati (Autonomous)

Course Structure for (M.Sc. Mathematics) Part-I (2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
I	Major (Mandatory)	MAT-501-MJM	Measure Theory and Integration	Theory	04
	Major (Mandatory)	MAT-502-MJM	Advanced Calculus	Theory	04
	Major (Mandatory)	MAT-503-MJM	Practical in Ordinary Differential Equations	Practical	02
	Major (Mandatory)	MAT-504-MJM	Programming in C	Practical	02
	Major (Elective)	MAT-511-MJE (A)	Numerical Analysis	Theory	04
		MAT-511-MJE (B)	Group Theory	Theory	
	Research Methodology (RM)	MAT-521-RM	Research Methodology	Theory	04
	Total Credits Semester I				**20**
II	Major (Mandatory)	MAT-551-MJM	Complex Analysis	Theory	04
	Major (Mandatory)	MAT-552-MJM	Topology	Theory	04
	Major (Mandatory)	MAT-553-MJM	Practical in Partial Differential Equations	Practical	02
	Major (Mandatory)	MAT-554-MJM	Programming in C++	Practical	02
	Major (Elective)	MAT-561-MJE(A)	Number Theory	Theory	04
		MAT-561-MJE(B)	Rings and Modules	Theory	
	On Job Training (OJT)/Field Project (FP)	MAT-581-OJT/FP	On Job Training Filed Project	Training/ Project	04
	Total Credits Semester-II				**20**
Cumulative Credits Semester I and II					**40**

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the Programme	**:** M.Sc (Mathematics)
Program Code	**:** PSMAT
Class	**:** M.Sc.I
Semester	**:** II
Course Type	**:** Major (Mandatory)
Course Name	**:** Complex Analysis
Course Code	**:** MAT-551-MJM
No. of Lectures	**:** 60
No. of Credits	**:** 4

Course Objectives:

1. To understand and learn to use Argument principle.
2. To study techniques of complex variables and functions together with their derivative, Contour integration and transformation.
3. To study complex power series and classification of singularities.
4. To study calculus of residue and its applications in the evaluation of integrals.
5. To understand range of analytic functions.
6. To understand the modulus of a complex valued functions and results regarding that,
7. To understand Gamma and Zeta functions, their properties and relationships.

Course Outcomes:

By the end of the course, students will be able to:

CO1: Represent complex numbers algebraically and geometrically.
CO2: Analyze limit, continuity and differentiation of functions of complex variables.
CO3: Understand Cauchy-Riemann equations, analytic functions and various properties of analytic functions.
CO4: Understand Cauchy theorem and Cauchy integral formula and apply these to evaluate complex contour integrals.
CO5: Classify singularities and poles and evaluate complex integration using the residue theorem.
CO6: Understand conformal mapping.
CO7: Find the Taylor's series of a function and determine its circle of convergence.

Topics and Learning Points

	Teaching Hours
UNIT1: The Complex number system	**04**
1.1 The field of Complex numbers	
1.2 The Complex plane	
1.3 Polar representation and roots of complex numbers	
1.4 Lines and half planes in the Complex plane	
UNIT2: Elementary properties and examples of Analytic functions	**16**
2.1 Power Series	
2.2 Analytic Functions	
2.3 Analytic functions as mapping, Mobius transformation	
UNIT3: Complex Integration	**16**
3.1 Power series representation of analytic functions	
3.2 Zeros of analytic function	
3.3 The index of a closed curve	
3.4 Cauchy's Theorem and Integral formula	
3.5 The homotopic version of Cauchy's Theorem and simple connectivity	
3.6 Counting zeroes; the Open Mapping Theorem	
3.7 Goursat's Theorem	
UNIT4: Singularities	**16**
4.1 Classification of singularities	
4.2 Residues	
4.3 The Argument Principle	
UNIT5: The Maximum Modulus Theorem	**08**
5.1 The Maximum Principle	
5.2 Schwarz's Lemma	
5.3 The gamma function	
5.4 The Riemann zeta function	

Text Book:

John B. Conway: Functions of one complex variable (Narosa Publishing house)

UNIT1: Sections 1.2 to 1.5
UNIT2: Sections 3.1 to 3.3
UNIT3: Sections 4.2 to 4.8
UNIT4: Sections 5.1 to 5.3
UNIT 5: Sections 6.1 to 6.2 and 7.7 to 7.8.

Reference Books:

1. S. Ponnusamy, Foundation of Complex Analysis, Narosa Publications, Second Edition.
2. E. Stein and Shakarchi, Complex Analysis, Overseas Press (India) Ltd.
3. Lars V. Ahlfors, Complex Analysis, McGrawHill.
4. Ruel V. Churchill, James Ward Brown, Complex Variables and Applications, McGraw Hill.
5. Anant R. Shastri, Basic Complex Analysis of One Variable, Macmillan publishers India, 2010.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc-I (Sem II) **Subject:** Mathematics
Course: Complex analysis **Course Code:**-MAT-551-MJM
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	1							
CO 2	3	2		2					1
CO 3	2	2							
CO 4	3	3							
CO 5	2	3			1				
CO 6	2	3			1				
CO 7	2	3		2					2

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: The Argument Principle provides a systematic framework for analyzing and evaluating the logical and persuasive aspects of disciplinary knowledge, enhancing critical thinking and communication skills.

CO2: Studying complex variables, derivatives, contour integration, and transformations enhances critical thinking and problem-solving by providing powerful mathematical tools to analyze and solve complex real-world problems.

CO3: Studying complex power series and the classification of singularities is essential in disciplinary knowledge as it provides a deeper understanding of the behaviour of complex functions, enabling the accurate analysis and modelling of phenomena in various scientific and engineering fields..

CO4: Studying the calculus of residues and its applications is crucial in disciplinary knowledge because it equips individuals with a powerful technique for efficiently evaluating complex integrals, which is invaluable in solving intricate problems in mathematics, physics, engineering, and various scientific disciplines..

CO5: Understanding the range of analytic functions is fundamental in disciplinary knowledge as it provides insights into the behaviour and limitations of functions used in various scientific and mathematical applications, enabling more accurate and informed analyses and problem-solving.

CO6: Understanding the modulus of complex-valued functions and related results is crucial in disciplinary knowledge for assessing magnitudes, oscillations, and critical properties of functions, facilitating precise analysis and predictions in scientific and engineering domains.

CO7: Understanding Gamma and Zeta functions, their properties, and relationships is essential in disciplinary knowledge as they play a pivotal role in advanced mathematical and scientific computations, offering valuable tools for solving complex problems and modelling real-world phenomena.

PO2: Critical Thinking and Problem solving

CO1: Learning the Argument Principle enhances critical thinking and problem-solving skills by providing a systematic approach to analyze and evaluate the logical and persuasive aspects of complex issues and arguments.

CO2: Studying complex variables, derivatives, contour integration, and transformations fosters critical thinking and problem-solving by equipping individuals with powerful mathematical tools that enable the analysis and resolution of complex, real-world problems across various disciplines.
CO3: Studying complex power series and the classification of singularities enhances critical thinking and problem-solving by providing a deep understanding of the behaviour of complex functions, enabling more accurate and sophisticated analysis of intricate mathematical and scientific problems.
CO4: Studying the calculus of residue and its applications is essential for critical thinking and problem-solving as it equips individuals with a powerful technique for efficiently evaluating complex integrals, making it a valuable tool in solving intricate problems in mathematics, physics, and engineering.
CO5: Understanding the range of analytic functions is essential for critical thinking and problem-solving because it provides insights into the behaviour and limitations of functions used in various scientific and mathematical applications, enabling more accurate analysis and informed problem-solving across disciplines.
CO6: Understanding the modulus of complex-valued functions and related results is crucial for critical thinking and problem-solving as it aids in assessing magnitudes, oscillations, and critical properties of functions, facilitating precise analysis and predictions in scientific and engineering contexts.
CO7: Understanding Gamma and Zeta functions, their properties, and relationships is vital for critical thinking and problem-solving, as they provide powerful mathematical tools for advanced computations and modelling in diverse scientific and engineering applications.

PO4: Research-related skills and Scientific temper
CO2: Studying complex variables, derivatives, contour integration, and transformations cultivates research-related skills and a scientific temper by equipping individuals with advanced mathematical tools crucial for conducting rigorous analyses and investigations in diverse scientific disciplines.
CO7: Understanding Gamma and Zeta functions, their properties, and relationships fosters research-related skills and a scientific temper, as these functions play a fundamental role in advanced mathematical research, facilitating precise modeling and analysis in scientific inquiries and investigations.

PO5: Trans-disciplinary knowledge
CO5: Understanding the range of analytic functions is crucial for trans-disciplinary knowledge as it equips individuals with a foundational mathematical concept essential for diverse applications across various fields, fostering a holistic approach to problem-solving.

CO6: Understanding the modulus of complex-valued functions and related results is essential for trans-disciplinary knowledge, as it provides a common mathematical language for analyzing and comparing data and phenomena across different disciplines, promoting interdisciplinary collaboration and problem-solving.

PO9: Self-directed and Life-long learning:
CO2: Studying techniques of complex variables, derivatives, contour integration, and transformation supports self-directed and life-long learning by equipping individuals with powerful mathematical tools that can be applied across a wide range of contexts and disciplines, promoting ongoing personal and professional development.

CO7: Understanding Gamma and Zeta functions, their properties, and relationships contributes to self-directed and life-long learning by providing individuals with advanced mathematical knowledge that can be continually applied and expanded upon, fostering a commitment to ongoing intellectual growth and problem-solving capabilities.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the Programme	: M.Sc (Mathematics)
Program Code	: PSMAT
Class	: M.Sc.I
Semester	: II
Course Type	: Major (Mandatory)
Course Name	: Topology
Course Code	: MAT-552-MJM
No. of Lectures	: 60
No. of Credits	: 4

Course Objectives:

1. To develop the student's ability to handle abstract ideas of Mathematics and Mathematical proofs.
2. To introduce the fundamental ideas of Topological Spaces.
3. To provide knowledge of the point set topology and understand the significance of topology and metric spaces
4. To acquaint students with homeomorphism and some topological properties like connectedness, compactness, etc.
5. To introduce the properties of continuous mappings and basic theorems on topological spaces.
6. To get familiar with concepts such as basis, open sets, closed sets, interior, closure and boundary etc.
7. Create new topological spaces by using subspace, product and quotient topologies etc.

Course Outcomes:

By the end of the course, students will be able to:

CO1: Construct maps between topological spaces.
CO2: Understand difference between Metric Spaces and Topological Spaces.
CO3: Classify certain topological spaces based on topological properties like Connectedness and compactness.
CO4: Understand the separation axioms, metrizable spaces, first and second countability axioms among various spaces.
CO5: Demonstrate an understanding of the concepts of metric spaces and topological spaces, and their role in mathematics.
CO6: Prove basic results about completeness, compactness, connectedness and convergence within these structures.
CO7: Prepare for studying advanced research level courses on Topology.

Topics and Learning Points

	Teaching Hours
UNIT1: Topological Spaces	**15**
1.1 Finite sets	
1.2 Countable and Uncountable Sets	
1.3 Well Ordered Sets	
1.4 Topological Spaces	
1.5 Basis for a Topology	
1.6 Order Topology	
1.7 Product Topology on $X \times Y$	
1.8 Subspace Topology	
UNIT2: Continuous Functions	**10**
2.4 Closed Sets and Limit Points	
2.5 Continuous Functions	
2.6 The Product Topology, Metric Topology	
2.7 Quotient Topology	
UNIT3: Connected and Compact Spaces	**20**
3.1 Connected spaces	
3.2 Connected Subspaces of Real Line	
3.3 Components and Local Connectedness	
3.4 Compact spaces	
3.5 Compact Subspaces of the Real Line	
3.6 Limit point compactness	
3.7 Local Compactness	
UNIT4: Countability and Separation Axioms	**15**
4.1 The Countability Axioms	
4.2 The Separation axioms and Normal Spaces	
4.3 Urysohn Lemma	
4.4 The Urysohn Metrization Theorem (Without proof)	
4.5 Tietze Extension Theorem (Without proof)	
4.6 Tychonoff's Theorem (Without proof)	

Text Book:

James R. Munkres, Topology Second Edition (Prentice Hall), 2000.

Unit 1- Chapter 1: 6, 7, 10, Chapter 2: 12 to 16.
Unit 2- Chapter 2: 17 to 22.
Unit 3- Chapter 3: 23 to 29.
Unit 4- Chapter 4: 30 to 35, Chapter 5: 37.

References:

1. J. L. Kelley, General Topology, Springer.
2. Sidney A. Morris, Topology without Tears.
3. S. Willard, General Topology, Addison-Wesley Publishing Company
4. L.A. Steen and J.A. Seebach Jr., Counterexamples in Topology.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc. (Sem I) **Subject:** Mathematics
Course: Topology **Course Code:** MAT-552-MJM
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes(POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							
CO 2	3	2							
CO 3	3	2							2
CO 4	3	2							
CO 5	3					2			
CO 6		2							
CO 7				3		2			2

Justification for the mapping

PO 1: Disciplinary Knowledge:
CO1: Student will master in the map construction of topological spaces.
CO2: Student will develop a deep understanding of difference between Metric and Topological spaces.
CO3: Students will demonstrate the classification of topological spaces based on knowledge of topological properties.
CO4: Student will develop understanding of separation axioms, metrizable spaces and countability axioms.
CO5: Student will demonstrate concepts of Metric spaces and their role in other subjects.

PO 2: Critical Thinking and Problem Solving:
CO1: Student will apply their knowledge of topological spaces and solve the problem of map construction.
CO2: Student will apply their knowledge and find the difference between Metric spaces and Topological spaces.
CO3: Students will use the knowledge of topological properties and classified topological spaces.
CO4: Student will use their understanding of separation axioms, metrizable spaces and countability axioms and solve problems on it.
CO6: Students will prove basic results of compactness and completeness within the structure.

PO 4: Research-related skills and Scientific temper:
CO 7: Students will apply mathematical concepts to further research and study of advanced subjects.

PO6: Personal and professional competence:
CO5: Students will demonstrate the ability to apply concepts of Metric space, Topological space and their role in mathematics.
CO7: Students will demonstrate the ability to work independently and solve various practical problems. This integrated approach prepares students for the challenges.

PO9: Self-directed and Life-long learning:
CO3: Students will demonstrate the ability to classified Topological spaces and solve practical problems.
CO7: Students will demonstrate the ability to apply topological concepts for advanced study which is helpful for self-improvement.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester II

Course Type : Major (Mandatory)

Course Name : Practical in Partial Differential Equations

Course Code : MAT-553-MJM

No. of Lectures : 60

No. of Credits : 2

Course Objectives:

1. To develop an understanding of numerical methods for partial differential equations.
2. To familiarize the students with first and higher order partial differential equations and their classification.
3. Students will learn the separation of variables method to solve linear parabolic, elliptic and hyperbolic partial differential equations.
4. Applications of partial differential equations in other subject and real world problems.
5. To apply problem solving using concepts & techniques from partial differential equations & Fourier analysis applied to diverse situations in physics, engineering, financial mathematics & in other mathematical context.
6. To introduce various applications of PDEs in many fields of science.
7. Determine the order and classification of PDEs.

Course Outcomes:

By the end of the course, students will be able to:

CO1: Student will be able to understand the formation and solution pf PDE of first and second order.

CO2: Student will solve first order linear and non Linear PDE by using Charpit and Jacobi method.

CO3: Student will be able to understand the basic properties of standard PDE's

CO4: Student will be able to use PDE's to find solutions of wave equation and laplace equation.

CO5: Student will be able to understand how to solve the given standard partial differential equations.

CO6: Students will be able to determine the type of a second order PDE.

CO7: Students should be able to distinguish between linear, nonlinear PDEs.

Topics and Learning Points

	Teaching Hours
Unit 1 Pfaffian Differential Equations	**15**
1.1 Genesis of first order P.D.E.	
1.2 Classification of integrals	
1.3 Linear equations of the first order	
1.4 Pfaffian differential equations	
Unit 2 Charpit's and Jacobi's methods	**15**
2.1 Compatible systems of first order P.D.E.	
2.2 Charpit's Method	
2.3 Jacobi's Method	
Unit 3 Classification of Second Order P.D.E.	**15**
3.1 Genesis of second order P.D.E	
3.2 Classification of second order P.D.E.	
3.3 One Dimensional Wave Equation	
Unit 4 : Applications of Second Order P.D.E.	**15**
4.1 Laplace's equation	
4.2 Heat Conduction Problem	

Text Book:

T. Amarnath, An Elementary Course in Partial Differential Equations, 2nd edition, Narosa Publishing House.

UNIT 1: Sections 1.2 to 1.5
UNIT 2: Sections 1.6 to 1.8
UNIT 3: Sections 2.1 to 2.2 and 2.3.1, 2.3.2, 2.3.3
UNIT 4: Sections 2.4 (2.4.1, 2.4.3, 2.4.4, 2.4.5) and 2.5(2.5.1, 2.5.2).

References:

1. K. Sankara Rao, Introduction to partial differential equation, third edition.
2. I.N. Sneddon, Elements of partial differential equations, Mc-Graw Hill Book Company.
3. W. E. Williams, Partial Differential equations, Clarendon press-oxford.
4. E. T. Copson, Partial differential equations, Cambridge university press.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc (Sem II) **Subject:** Mathematics

Course: Practical in Partial Differential Equations **Course Code:** MAT-553-MJM

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	2		1	2				
CO 2	3	1		3					
CO 3	2	2							
CO 4	2	3	2					1	3
CO 5	3	3			2				
CO 6	3	3		2	3				
CO 7	3	1					2		1

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Studying the formation and solution of first and second-order Partial Differential Equations (PDEs) is essential for students to gain a foundational understanding of mathematical tools that are widely applied across various disciplines, enabling them to analyze complex physical phenomena and make informed decisions in their respective fields.

CO2: Students will learn to solve first-order linear and nonlinear partial differential equations (PDEs) using Charpit's method for linear PDEs and Jacobi's method for nonlinear PDEs, enhancing their disciplinary knowledge in mathematical methods for PDE analysis..

CO3: Studying standard partial differential equations (PDEs) equips students with a fundamental understanding of the core properties and principles governing a wide range of natural phenomena, facilitating their grasp of disciplinary knowledge.

CO4: Students will acquire the essential skill of utilizing partial differential equations (PDEs) to solve problems related to the wave equation and Laplace's equation, enhancing their disciplinary knowledge in mathematical and physical sciences.

CO5: This learning outcome ensures that students acquire the ability to solve standard partial differential equations within their specific disciplinary knowledge area, facilitating their comprehension of fundamental mathematical concepts in their field of study.

CO6: This knowledge allows students to analyse and solve complex physical and mathematical problems by identifying the underlying governing equation, which is essential in various scientific and engineering disciplines.

CO7: Distinguishing between linear and nonlinear partial differential equations (PDEs) is crucial for understanding the fundamental behaviour of physical systems and mathematical modelling, facilitating more accurate problem-solving in various disciplines.

PO2: Critical Thinking and Problem solving

CO1: Studying the formation and solution of first and second-order partial differential equations (PDEs) enhances students' critical thinking and problem-solving skills by providing a foundational understanding of mathematical modeling and analytical methods applicable in various scientific and engineering disciplines.
CO2: Students will develop critical thinking and problem-solving skills by solving first-order linear and nonlinear partial differential equations using the Charpit and Jacobi methods.
CO3: Studying standard PDEs enhances critical thinking and problem-solving skills by providing a foundation to analyze and solve complex mathematical and physical problems in various fields, fostering a deeper understanding of fundamental properties and behaviors.
CO4: Studying partial differential equations (PDEs) equips students with the critical thinking and problem-solving skills necessary to analyze and solve complex physical problems, particularly in scenarios involving wave and Laplace equations, fostering a deeper understanding of mathematical and physical principles.
CO5:Teaching standard partial differential equations cultivates critical thinking and problem-solving skills in students by providing them with the knowledge and tools to tackle complex mathematical problems.
CO6: Students can identify the type of a second-order partial differential equation through critical thinking and problem-solving by analyzing its coefficients and characteristics to classify it as elliptic, parabolic, or hyperbolic.
CO7: Students should be able to distinguish between linear and nonlinear partial differential equations (PDEs) to develop critical thinking and problem-solving skills, as it enables them to apply appropriate mathematical techniques and strategies when addressing real-world problems with varying degrees of complexity.

PO3: Social competence
C04: Teaching students how to solve wave and Laplace equations through partial differential equations (PDEs) enhances their social competence by fostering problem-solving skills and critical thinking, which are transferable to various real-world challenges.

PO4: Research-related skills and Scientific temper
CO1: Studying the formation and solution of first and second-order partial differential equations (PDEs) fosters research-related skills and a scientific temper by cultivating a foundational understanding of mathematical modeling and problem-solving in various scientific disciplines.
CO2: Students will develop research-related skills and a scientific temper by mastering the Charpit and Jacobi methods to solve first-order linear and nonlinear partial differential equations, enhancing their ability to tackle complex mathematical problems and fostering a deep understanding of the subject matter.
CO6: Studying second order partial differential equations (PDEs) cultivates research-related skills and fosters a scientific temper by enabling students to classify and analyze PDEs, a fundamental tool in various scientific disciplines..

PO5: Trans-disciplinary knowledge

CO1: Studying the formation and solution of first and second-order partial differential equations (PDEs) provides students with trans-disciplinary knowledge by fostering a deep understanding of mathematical modeling and its applications across various fields, from physics and engineering to economics and biology.

CO5: Studying standard partial differential equations fosters trans-disciplinary knowledge by providing students with a fundamental tool to model and analyze complex phenomena across various fields, from physics and engineering to economics and biology.
CO6: Studying second-order partial differential equations (PDEs) equips students with the ability to discern the PDE's type and promotes trans-disciplinary knowledge by fostering an understanding of mathematical principles applicable across various fields.

PO7: Effective Citizenship and Ethics

CO7: Students should be able to distinguish between linear and nonlinear PDEs in self-directed and life-long learning to understand the fundamental classification that dictates the behavior and solutions of partial differential equations, enabling them to apply appropriate methods and techniques in various fields throughout their educational and professional journeys.

PO8 :Envionment and Sustainability :

CO4: Students will use PDEs to address environmental and sustainability challenges by modeling wave propagation and spatial distribution in the context of the wave equation and Laplace equation, enabling informed decision-making for sustainable practices.

PO9: Self-directed and life –long learning :

CO4: Mastering PDEs for wave and Laplace equations fosters self-directed and life-long learning by equipping students with essential problem-solving skills for diverse real-world applications in physics, engineering, and beyond.
CO7: Students should be able to distinguish between linear and nonlinear PDEs in self-directed and life-long learning to develop a foundational understanding of mathematical models that underpin a wide range of real-world phenomena, enabling them to adapt and apply their knowledge effectively in diverse problem-solving contexts.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the programme	: M.Sc. (Mathematics)
Program Code	: PSMAT
Class	: M.Sc. -I
Semester	: II
Course Type	: Major (Mandatory)
Course Name	: Practical programming in C++
Course Code	: MAT-554-MJM
No. of Lectures	: 60
No. of Credits	: 2

Course Objectives:

1. To understand basic programming in C++.
2. To study mathematics using programming and the basic syntax of c++.
3. Understand the OOP principles, objects, inheritance and polymorphism.
4. Understand the proficiency in using pointers and references to work.
5. To develop and understand the representation of numbers in c++.
6. Solve a specific problem or perform a task efficiently using C++.
7. Break the program into smaller, functions for easier maintenance and understanding.

Course Outcomes:

By the end of the course, students will be able to:

CO1: Describe and use constructors and destructors
CO2: Use fundamentals of C programming to implement algorithms in mathematics.
CO3: Develop a C ++ program.
CO4: Exploring C++ programming.
CO5: Managing input and output operations.
CO6: Understand the basics of file handling mechanisms.
CO7: Solve repetitive work using C++ programming.

Topics and Learning Points

Teaching Hours

Theory: Programming in C++ **12**

1. Beginning with C++ and OOP programming.
2. Functions in C++ and Classes and objects.
3. Constructors and Destructors.
4. Operator overloading and type conversions
5. Inheritance: Extending classes
6. Pointers, virtual Functions and Polymorphism

Practical's: **48**

1. Average of numbers and some basic operations on numbers
2. Identify the numbers i.e. prime number,odd number, even number.
3. Quadratic equation solver.
4. To use of class and Inline function.
5. Matrix calculator
6. Nesting of member function and arrays within a Class
7. Statistical Analysis Tool.
8. Fraction simplifier.
9. Complex number calculator
10. To use of constructors and destructors
11. Overloading Unary and Binary operator
12. Mathematical operations on string and Inheritance.

Text Book:

E Balagurusamy, Object Oriented Programming with C++

Reference Books:

1. Byron Gottfried, Schaum's series programming with C++.
2. Yashwant Kanetkar, Let us C++.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc (Sem II) **Subject:** Mathematics

Course: Practical programming in C++ **Course Code:** MAT-554-MJM

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1									
CO 2	3	2							
CO 3	3	3		3	2				2
CO 4	2	3		3					3
CO 5	2	1							
CO 6	3	3					1		
CO 7	3	3	2	3				1	

Justification for the mapping

PO1: Disciplinary Knowledge

CO2: Using C++ programming fundamentals to implement mathematical algorithms enables efficient and precise numerical computations, facilitating solutions to complex mathematical problems in various disciplines.
CO3: Develop a C++ program to enhance disciplinary knowledge and practical skills in software development and problem-solving.
CO4: Exploring C++ programming enhances disciplinary knowledge by providing a strong foundation in a versatile and widely used programming language, enabling problem-solving and software development skills across various domains.
CO5: Managing input and output operations is essential for efficient data communication and storage, ensuring proper handling of information in various computing and data-driven systems.
CO6: Understanding file handling mechanisms is crucial for effective data management and ensures compliance with data integrity and security protocols in various disciplinary domains.
CO7: C++ programming enables automation and efficiency by eliminating manual, repetitive tasks through its powerful and versatile features.

PO2: Critical Thinking and Problem solving

CO2: Using C programming fundamentals to implement mathematical algorithms enhances critical thinking and problem-solving skills by applying logic and abstraction to solve complex mathematical problems efficiently.
CO3: Developing a C++ program fosters critical thinking and problem-solving skills by requiring logical analysis, algorithmic design, and troubleshooting to create efficient and functional software solutions.

CO4: Exploring C++ programming enhances critical thinking and problem-solving skills by fostering logical and structured thinking in solving complex programming challenges.
CO5: Managing input and output operations is essential for critical thinking and problem solving as it ensures data accessibility and enables the analysis and manipulation of information, a fundamental aspect of effective decision-making and creative problem-solving.
CO6: Understanding file handling mechanisms is critical for critical thinking and problem-solving as it enables efficient data management, troubleshooting, and the development of creative solutions for various technical challenges.
CO7: C++ programming automates repetitive tasks, enhancing critical thinking by allowing developers to focus on solving unique challenges rather than manual, redundant operations.

PO3: Social competence
C07: Using C++ programming to automate repetitive tasks enhances social competence by freeing up time for meaningful interactions and collaboration with others.

PO4: Research-related skills and Scientific temper
CO3: Developing a C++ program enhances research-related skills and promotes a scientific temper by fostering critical thinking, problem-solving, and structured experimentation in software development.
CO4: Exploring C++ programming fosters research-related skills and a scientific temper by promoting problem-solving, critical thinking, and a systematic approach to software development.
CO7 : C++ programming automates repetitive tasks, enhancing research-related skills and fostering a scientific temper by streamlining data analysis and experimentation.

PO5: Trans-disciplinary knowledge
CO3: Developing a C++ program promotes trans-disciplinary knowledge by enhancing problem-solving skills and facilitating collaboration across diverse fields through the application of programming in various domains.

PO7: Effective Citizenship and Ethics

CO6: Understanding the basics of file handling mechanisms promotes responsible and ethical digital citizenship by enabling users to manage and share information securely and ethically.

PO8 : Envionment and Sustainability :

CO7: C++ programming can automate repetitive tasks, reducing manual effort and promoting environmental sustainability by optimizing resource utilization and minimizing errors.

PO9: Self-directed and life –long learning :

CO3: Developing a C++ program fosters self-directed and lifelong learning by enhancing problem-solving skills, programming proficiency, and adaptability in a rapidly evolving technological landscape.
CO4: Exploring C++ programming promotes self-directed and lifelong learning by fostering continuous skill development and adaptability in the ever-evolving field of computer science.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester : II

Course Type : Major (Elective)

Course Name : Number Theory

Course Code : MAT-561-MJE (A)

No. of Lectures : 60

No. of Credits : 4

Course Objectives:

1. To impart the knowledge of encryption and decryption techniques and their applications in managing the security of data.
2. To express the concept and results of number theory effectively.
3. To learn various arithmetic functions, Sigma function, Algebraic Numbers, and congruence relation.
4. To identify and characterize prime numbers, and recognize their significance.
5. To Learn about divisibility rules, and prime factorization.
6. To give elementary ideas from number theory this will have applications in various fields.
7. To introduce the concepts of Quadratic reciprocity.

Course Outcomes:

By the end of the course, students will be able to:

CO1: Find the quotients and remainders from integer division.
CO2: Understand the definitions of congruence, residue classes and least residues.
CO3: Identify arithmetic functions and Dirichlet multiplications.
CO4: To establish existing identities using Mobius inversion formula.
CO5: Determine multiplicative inverses modulo n, and use to solve linear congruence.
CO6: Apply the Wilsons theorem and calculate primitive roots.
CO7: Understand the concepts of legendry symbol and identify the Quadratic or non-Quadratic residues modulo p.

Topics and Learning Points

	Teaching Hours
Unit 1: Divisibility	**10**
1.1 Divisibility in integers	
1.2 Division algorithm	
1.3 G.C.D, L.C.M	
1.4 Fundamental theorem of arithmetic	
1.5 The number of primes	
1.6 Mersene numbers and Fermat numbers	
Unit 2: Congruences	**13**
2.1 Properties of congruence relation	
2.2 Residue classes their properties Fermat's and Euler's theorems	
2.3 Wilson's Theorem	
2.4 Linear congruence of degree one	
2.5 Chinese remainder theorem	
Unit 3: Arithmetic functions	**10**
3.1 Euler function	
3.2 Greatest integer function	
3.3 Divisor function $\delta(n)$	
3.4 Mobius function $\mu(n)$	
3.5 Properties and their inter relation.	
Unit 4: Quadratic Reciprocity	**15**
4.1 Quadratic residue.	
4.2 Legendre's symbol its properties	
4.3 Quadratic Reciprocity law	
4.4 Jacobi symbol its properties	
4.5 Sums of Two Squares	
Unit 5: Some Diophantine Equations	**04**
5.1 The equation $ax + by = c$	
5.2 Simultaneous linear equations	
Unit 6: Algebraic Numbers	**08**
6.1 Algebraic Numbers.	
6.2 Algebraic number fields.	
6.3 Algebraic integers.	
6.4 Quadratic fields.	
6.5 Units in Quadratic fields.	
6.6 Primes in Quadratic fields.	

Text Book:

Ivan Niven, H. S. Zuckerman, An introduction to number theory, Wiley Eastern Limited.

Unit 1: Sections 1.1 to 1.3
Unit 2: Sections 2.1 to Section 2.4
Unit 3: Section 3.1, 3.3, 3.6.
Unit 4: Section 4.1 to Section 4.4
Unit 5: Section 5.1 and Section 5.2
Unit 6: Section 9.1 to Section 9.7

Reference Books:

1. T.M. Apostol, An Introduction to Analytical Number Theory, Springer International Student's Edition.
2. David M Burton, Elementary Number Theory, Universal Book Stall, New Delhi.
3. S. G. Telang, Number Theory, Tata Mc-graw Hill.
4. W. Rudin, Functional Analysis, Tata McGraw Hill.
5. G. H. Hardy, E.M.Wright, Introduction to Number Theory, Oxford university press.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc. (Sem II) **Subject:** Mathematics

Course: Number Theory **Course Code:** MAT-561-MJE (A)

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2				1				
CO 2	2	2							
CO 3	2	2			2				
CO 4	3	3		2					3
CO 5	1	3							
CO 6	3	3			1				
CO 7	2	3							2

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Finding quotients and remainders from integer division is a fundamental operation in arithmetic and computer science, essential for tasks like modular arithmetic, algorithm design, and data structure implementation.

CO2: Understanding the definitions of congruence, residue classes, and least residues is essential for foundational comprehension in number theory and modular arithmetic.

CO3: Identifying arithmetic functions and Dirichlet multiplications is crucial in number theory to analyze the behavior of prime numbers and investigate their properties within the framework of multiplicative number theory.

CO4: The Mobius inversion formula is a powerful tool in number theory and combinatorics that allows us to recover existing identities and relationships by reversing the summation or convolution process, providing a systematic and efficient method for studying number-theoretic functions and relationships.

CO5: Determine multiplicative inverses modulo n to solve linear congruences, as these inverses allow for division in modular arithmetic, enabling the solution of equations of the form $ax \equiv b \pmod{n}$.

CO6: Applying Wilson's theorem helps identify the existence of primitive roots in modular arithmetic by revealing that if (p-1) is prime, then primitive roots exist modulo p.

CO7: Understanding legendary symbols is essential for identifying quadratic or non-quadratic residues modulo p in number theory and modular arithmetic, a key component of disciplinary knowledge.

PO2: Critical Thinking and Problem solving

CO2: Understanding the definitions of congruence, residue classes, and least residues is essential for critical thinking and problem-solving in number theory, modular arithmetic, and cryptography, enabling the manipulation and analysis of modular equations and their applications in diverse mathematical and real-world scenarios.
CO3 Identifying arithmetic functions and Dirichlet multiplications is essential for critical thinking and problem-solving in number theory, enabling the analysis and manipulation of number sequences and their properties to tackle complex mathematical problems..
CO4 The Mobius inversion formula is a powerful tool for unraveling existing identities by providing a systematic method to transform and solve problems involving arithmetic functions, fostering critical thinking and problem-solving skills in number theory and combinatorics.
CO5: Determine multiplicative inverses modulo n to solve linear congruences is critical for problem-solving in number theory and cryptography, as it enables efficient solutions to equations in modular arithmetic, a fundamental concept with various real-world applications.
CO6: Applying Wilson's theorem is a fundamental step in determining the existence of primitive roots, demonstrating a key aspect of critical thinking and problem-solving in number theory. CO7: Understanding legendary symbols is essential for distinguishing between quadratic and non-quadratic residues modulo p, a key component of critical thinking and problem-solving in number theory and cryptography.

PO4: Research-related skills and Scientific temper
CO4: The Mobius inversion formula is a powerful tool for revealing underlying patterns in existing identities, demonstrating critical research-related skills and a strong scientific temper in unravelling complex mathematical relationships.

PO5: Trans-disciplinary knowledge
CO1: "Find the quotients and remainders from integer division transcend disciplinary boundaries, applying to various fields of study."

CO3: Arithmetic functions are elementary number theory functions used in various mathematical disciplines, while Dirichlet multiplications are a tool in analytic number theory that combines functions to study number-theoretic properties in a trans-disciplinary approach.

CO6: Applying Wilson's theorem to calculate primitive roots enables us to bridge number theory with computational algebra, showcasing the power of trans-disciplinary knowledge.

PO7: Effective Citizenship and Ethics

CO7: Understanding polynomial rings and their properties can enhance mathematical reasoning skills, fostering a foundation for informed decision-making in various ethical and societal contexts.

PO9: Self-directed and Life-long learning:

CO4: The Mobius inversion formula enables the identification of underlying patterns and relationships, fostering self-directed and lifelong learning by revealing the interconnected nature of mathematical structures.

CO7: Self-directed and lifelong learning is essential for individuals to continually expand their knowledge and adapt to evolving challenges in an increasingly complex and dynamic world.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the programme	: M.Sc. (Mathematics)
Program Code	: PSMAT
Class	: M.Sc. -I
Semester	: II
Course Type	: Major (Elective)
Course Name	: Rings and Modulus
Course Code	: MAT-561-MJE(B)
No. of Lectures	: 60
No. of Credits	: 4

Course Objectives:

1. To understand the structure of a ring and its basic properties.
2. To understand the properties such as associativity, distributivity, and the existence of an additive identity and additive inverse.
3. To study importance of rings as a fundamental object in algebra.
4. To understand the concepts of modules as a generalization of vector spaces.
5. To know the interrelationship between Euclidean domains, principal ideal domains, and unique factorization domains.
6. To explain integral domains and fields as special types of rings.
7. To investigate polynomial rings and their properties.

Course Outcomes:

By the end of the course, students will be able to:

CO1: define a ring and recognize its fundamental properties, distinguishing it from other algebraic structure.
CO2: Understand the concept of ring homomorphisms, which are function preserves the ring structure.
CO3: Use knowledge of ideals in distinct subject problems.
CO4: To factor elements in a ring, including how to perform operations and factor polynomials within such rings.
CO5: Use the concept of ideals and how they relate to subrings, along with a deep knowledge of the quotient ring.
CO6: Understand the meaning of least common multiple of two polynomials.
CO7: Know how to add and multiply polynomials over arbitrary fields, and be able to use this to define polynomial rings.

Topics and Learning Points

	Teaching Hours
UNIT 1: Rings	**12**
1.1 Rings of continuous functions.	
1.2 Matrix Ring.	
1.3 Polynomial Rings.	
1.4 Power series Rings.	
1.5 Laurent Rings.	
1.6 Boolean Ring.	
1.7 Direct Products.	
1.8 Several Variables.	
1.9 Opposite Rings.	
1.10 Characteristic of a Ring.	
UNIT 2: Ideals	**12**
2.1 Maximal Ideals.	
2.2 Generators.	
2.3 Basic Properties of Ideals.	
2.4 Algebra of Ideals.	
2.5 Quotient Rings.	
2.6 Ideals in Quotient Rings.	
2.7 Local Rings.	
UNIT3: Homomorphism of Rings	**12**
3.1 Fundamental Theorems.	
3.2 Endomorphism Rings.	
3.3 Field of fractions.	
3.4 Prime field.	
UNIT4: Factorization in Domains	**14**
4.1 Division in Domains.	
4.2 Euclidean Domains.	
4.3 Principal Ideal Domains.	
4.4 Factorization Domains.	
4.5 Unique Factorization Domains.	
4.6 Eisenstein's Criterion.	
UNIT5: Modules	**14**
5.1 Direct Sum.	
5.2 Free Modules.	
5.3 Vector Spaces.	
5.4 Quotient Module.	
5.5 Homomorphism	
5.6 Simple Modules.	
5.7 Modules over PID's.	

Text Book:

C. Musili, Rings and Modules, Narosa Publishing House.

Unit 1: Section1.1.1 to 1.12

Unit 2: Section 2.1 to 2.8

Unit 3: Section3.1 to 3.5
Unit 4: Section4.1 to 4.6
Unit 5: Section5.1 to 5.8

Reference Books:

1. Bhattacharya, Nagpaul and Jain, Basic Abstract Algebra, Cambridge University Press.
2. Luther and Passi, Algebra II, Narosa Publishing House.
3. David S. Dummit, Richard M. Foote, Abstract Algebra.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc (Sem II) **Subject:** Mathematics
Course: Ring and Modules **Course Code:** MAT-561-MJE(B)
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	1			2				
CO 2	3	2							
CO 3	2	3			2				2
CO 4	3	2							
CO 5	2	2							
CO 6	2	3							
CO 7	2	3					1		

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Understanding the structure and basic properties of rings is fundamental in algebraic mathematics, providing a foundation for abstract algebra and its applications in various mathematical and scientific disciplines.

CO2: Understanding properties like associativity, distributivity, and the existence of additive identity and inverse is essential in mathematics as they form the basis for algebraic structures, underpinning various mathematical and scientific disciplines.

CO3: Studying the importance of rings as a fundamental algebraic object is crucial for a wide range of mathematical disciplines, as they serve as a cornerstone for abstract algebra and provide a versatile framework for solving mathematical problems and modeling various real-world phenomena..

CO4: Understanding modules as a generalization of vector spaces is essential in various mathematical and scientific disciplines, offering a more flexible framework for studying algebraic structures and linear transformations beyond vector spaces..

CO5: Knowing the interrelationship between Euclidean domains, principal ideal domains, and unique factorization domains is vital in algebra and number theory, providing insights into the

structure and factorization properties of integers and polynomials, which have applications in various mathematical disciplines..
CO6: Explaining integral domains and fields as special types of rings is essential in algebra and mathematical disciplines, as they represent algebraic structures with crucial properties, including divisibility, enabling the study of numbers and algebraic systems..
CO7: Investigating polynomial rings and their properties is essential in algebra and mathematics, serving as a foundational tool for studying functions, algebraic geometry, and various mathematical and scientific disciplines.

PO2: Critical Thinking and Problem solving

CO1: Understanding the structure of a ring and its basic properties is critical for developing problem-solving skills in algebra, fostering the ability to analyze abstract mathematical structures and apply them to real-world problems.
CO2: Analyzing the algebraic structure of a problem can help identify the underlying relationships and operations, aiding in critical thinking and problem solving.
CO3: Studying rings is crucial in critical thinking and problem solving, as they provide a versatile and abstract framework for understanding various algebraic structures, enhancing one's problem-solving abilities across diverse mathematical contexts.
CO4: Understanding modules as a generalization of vector spaces enhances critical thinking and problem-solving skills by providing a broader framework for solving diverse mathematical and real-world problems.
CO5: Understanding the interrelationship between Euclidean domains, principal ideal domains, and unique factorization domains enhances critical thinking and problem-solving abilities by providing a foundational grasp of the structures underlying number theory and abstract algebra, facilitating more effective problem-solving in related domains.
CO6: Understanding integral domains and fields as specialized rings is essential for critical thinking and problem solving in abstract algebra, as it allows for more precise and efficient mathematical modeling and problem-solving in a variety of contexts.
CO7: Exploring polynomial rings enhances critical thinking and problem-solving skills by offering insight into algebraic structures, equipping individuals with tools to solve a wide range of mathematical problems and real-world applications.

PO5: Trans-disciplinary knowledge

CO1: Understanding the structure of a ring and its basic properties is essential in transdisciplinary knowledge because it provides a universal framework for studying diverse mathematical and real-world systems that exhibit similar algebraic behaviors.

CO3: The study of rings in algebra is essential for building a strong foundation that transcends various disciplines, enabling a deeper understanding of abstract structures, which can be applied to fields ranging from number theory to computer science and beyond.

PO7: Effective Citizenship and Ethics

CO7: Understanding polynomial rings and their properties can enhance mathematical reasoning skills, fostering a foundation for informed decision-making in various ethical and societal contexts.

PO9: Self-directed and Life-long learning:

CO3: Understanding rings as a fundamental algebraic structure is essential for self-directed lifelong learning in algebra, providing a solid foundation for advanced mathematical concepts and problem-solving skills.

CBCS Syllabus as per NEP 2020 for M.Sc. I
(2023 Pattern)

Name of the Programme : M.Sc. (Mathematics)
Program Code : PSMAT
Class : M.Sc.I
Semester : II
Course Type : OJT/FP
Course Name : On Job Training
Course Code : MAT-581-OJT/FP
No. of Lectures : 60
No. of Credits : 4

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Examination Pattern / Evaluation Pattern

Teaching and Evaluation (for Major, Minor, AEC, VEC, IKS courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	4 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Teaching and Evaluation (for VSC, SEC & CC courses)

- Evaluation to be done by Internal & External Experts
- No descriptive end semester written examination
- Evaluation to be done at Department level preferably prior to commencement of Theory /Practical Examinations
- Evaluation to be done on the Skills gained by student