UNIVERSITY OF JAMMU

(NAAC ACCREDITED 'A ++' GRADE' UNIVERSITY)
Baba Sahib Ambedkar Road, Jammu-180006 (J&K)

Academic Section
Email: academicsectionju14@gmail.com

NOTIFICATION
(25/July/Adp./21)

It is hereby notified for the information of all concerned that the Vice-Chancellor, in anticipation of the approval of the Academic Council, is pleased to authorize the adoption of the syllabi and courses of studies for **Post Graduate Programme** in **Mathematics** under **NEP-2020** as per details given below:-

Two Year Post Graduate Programme under NEP-2020

Subject	Semester	For the examinations to be held in the year
Mathematics	Semester-I	December 2025, 2026 and 2027
	Semester-II	May 2026, 2027 and 2028
	Semester-III	December 2026, 2027 and 2028
	Semester-IV	May 2027, 2028 and 2029

One Year Post Graduate Programme under NEP-2020

Subject	Semester	For the examinations to be held in the year
Mathematics	Semester-I	December 2026, 2027 and 2028
	Semester-II	May 2027, 2028 and 2029

The Syllabi of the courses are also available on the University website: www.jammuuniversity.ac.in

Anju Bhasin 29/7/2025
DEAN ACADEMIC AFFAIRS

No. F. Acd/II/25/4983-5018
Dated: 30/7/2025

Copy for information and necessary action to:

1. Dean, Faculty of Mathematical Science
2. Convener, Board of Studies in **Mathematics**
3. Director, Centre for IT Enabled services and Management, University of Jammu for information and for uploading on University Website.
4. All members of the Board of Studies
5. Joint Registrar (Evaluation/P.G. Exam.)
6. Programmer, Computer Section, Examination Wing

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

Programme Code:- PGFMM004

The Two Years Postgraduate Program in Mathematics of University of Jammu is a two-year program in the regular mode consisting of four semesters and carries 96 credits with each Course of 5 Credits (5 credits are divided into two parts: 4 credits for Theory (Th) and 1 credit for Practicals/Tutorials (P/T)) and the Research Thesis/Project/Patent in Semester IV shall carry 16 Credits. All courses in Semesters I and II are compulsory. In Semester III, first three courses are compulsory and students can choose any two courses out of rest of the given courses whereas in Semester IV, students can choose any two courses out of the given list of courses and 16 credits Research Thesis/Project/Patent is compulsory.

Details of the Structure of Semesters and Syllabi

Semester I

S. No.	Course Code	Course Title	Course Level	Course Credits (Th + P/T)
1	P2MATC101	Ordinary and Partial Differential Equations	400	4 + 1
2	P2MATC102	Calculus of Functions of Several Variable	400	4 + 1
3	P2MATC103	Topology	400	4 + 1
4	P2MATC104	Number Theory and Cryptography	400	4 + 1

Semester II

S. No.	Course Code	Course Title	Course Level	Course Credits (Th + P/T)
1	P2MATC201	Advanced Complex Analysis	500	4 + 1
2	P2MATC202	Functional Analysis	500	4 + 1
3	P2MATC203	Measure Theory	500	4 + 1
4	P2MATC204	Discrete Mathematics	400	4 + 1
5	P2MATC205	Research Methodology and Research & Publication Ethics	400	4 + 1

Vocational Course: Following vocational course is compulsory for those students who intend to exit the program after first year (after 2nd semester) with Postgraduate diploma in Mathematics.

S. No.	Course Code	Course Title	Course Level	Course Credits
1	P2MAVC251	Computational tools for Mathematics	400	4

Semester III

S. No.	Course Code	Course Title	Course Level	Course Credits (Th + P/T)
1	P2MATC301	Field Extensions and Galois Theory	500	4 + 1
2	P2MATC302	Integral Equations and Calculus of Variation	500	4 + 1
3	P2MATC303	Linear Programming and Optimization Techniques	500	4 + 1
4	P2MATE304	Fundamentals of Computer for Mathematics	500	4 + 1
5	P2MATE305	Applied Linear Algebra	500	4 + 1
6	P2MATE306	Geometric Function Theory	500	4 + 1
7	P2MATE307	Complex Dynamics	500	4 + 1
8	P2MATE308	Advanced Topology	500	4 + 1
9	P2MATE309	Advanced Measure Theory	500	4 + 1
10	P2MATE310	Differential Geometry	500	4 + 1
11	P2MATE311	Dynamical System and Controls	500	4 + 1
12	P2MATE312	Mathematical Modeling	500	4 + 1
13	P2MAMO351	SWAYAM/MOOC Course	400	4

Semester IV

S. No.	Course Code	Course Title	Course Level	Course Credits (Th + P/T)
1	P2MATE401	Topological Vector Spaces	500	4 + 1
2	P2MATE402	Harmonic Mappings	500	4 + 1
3	P2MATE403	Uniform Spaces and Function Spaces	500	4 + 1
4	P2MATE404	Nevanlinna Value Distribution Theory	500	4 + 1
5	P2MATE405	Several Complex Variables	500	4 + 1
6	P2MATE406	Advanced Optimization Techniques	500	4 + 1
7	P2MATE407	Operator Theory	500	4 + 1
8	P2MATE408	Advanced Numerical Techniques	500	4 + 1
9	P2MARC409	Research Thesis/Project/Patent		16

Note 1: Practicals/Tutorials (P/T) shall be devoted to the tutorials in each semester and the evaluation shall be done through problem solving session. Weightage of marks shall be distributed uniformly through out all the courses offered in the semester.

Note 2: A 4-credit SWAYAM/MOOC course, preferably related to the domain knowledge of the student, is compulsory for Two year postgraduate program. Students must register for this course in December or January of the first year, and the credits will be accounted in the third semester. The credits earned through this course will be over and above the regular program credit requirements. For detailed instructions regarding SWAYAM/MOOC, students refer to Annexure-X.

Two Years Postgraduate Programme in Mathematics (1st Semester)																
S. No	Course No/Code	Course Title	No of Credits			Course Type	Marks		Nature of Course				SAWAM/MOOC	Vocational Course	Research Project/Summer Internship/Dissertation
				Credits Level	Credits Points	Course Elective/ Any Other	Theory	Practical/ Tutorial	Global	National	Regional	Skill			
1.	P2MATC101	Ordinary and Partial Differential Equations	4+1	6.5	32.5	Core	Theory		Global						
2.	P2MATC102	Calculus of Functions of Several Variables	4+1	6.5	32.5	Core	Theory		Global						
3.	P2MATC103	Topology	4+1	6.5	32.5	Core	Theory		Global						
4.	P2MATC104	Number Theory and Cryptography	4+1	6.5	32.5	Core	Theory		Global						

Two Years Postgraduate Programme in Mathematics (2nd Semester)

S. No	Course No/Code	Course Title	No of Credits	Credits Level	Credits Points	Course Type: Core Elective/ Any Other	Marks: Theory	Marks: Practical/ Tutorial	Nature of Course: Global	National	Regional	Skill	SAWYAM/MOOC	Vocational Course	Research Project/Summer Internship/Dissertation
1.	P2MATC201	Advanced Complex Analysis	4+1	6.5	32.5	Core	Theory		Global						
2.	P2MATC202	Functional Analysis	4+1	6.5	32.5	Core	Theory		Global						
3.	P2MATC203	Measure Theory	4+1	6.5	32.5	Core	Theory		Global						
4.	P2MATC204	Discrete Mathematics	4+1	6.5	32.5	Core	Theory		Global						
5.	P2MATC205	Research Methodology and Research & Publication Ethics	4+1	6.5	32.5	Core	Theory		Global						
6.	P2MAVC251*	Computational tools for Mathematics	4	6.5	26	Core	Theory		Global					Vocational Course	

*Vocational Course: Following vocational course is compulsory for those students who intend to exit the program after first year (after 2nd semester) with Postgraduate diploma in Mathematics.

Two Years Postgraduate Programme in Mathematics (3rd Semester)

S. No	Course No/Code	Course Title	No of Credits	Credits Level	Credits Points	Course Type: Course Elective/ Any Other	Marks: Theory	Marks: Practical/ Tutorial	Nature of Course: Global	Nature of Course: National	Nature of Course: Regional	Nature of Course: Skill	SAWYAM/MOOC	Vocational Course	Research Project/Summer Internship/Dissertation
1.	P2MATC301	Field Extensions and Galois Theory	4+1	6.5	32.5	Core	Theory		Global						
2.	P2MATC302	Internal Equations and Calculus of Variation	4+1	6.5	32.5	Core	Theory		Global						
3.	P2MATC303	Linear Programming and Optimization Techniques	4+1	6.5	32.5	Core	Theory		Global						
4.	P2MATE304	Fundamental of Computer for Mathematics	4+1	6.5	32.5	Elective	Theory		Global			Skill			
5.	P2MATE305	Applied Linear Algebra	4+1	6.5	32.5	Elective	Theory		Global						
6.	P2MATE306	Geometric Function Theory	4+1	6.5	32.5	Elective	Theory		Global						
7.	P2MATE307	Complex Dynamics	4+1	6.5	32.5	Elective	Theory		Global						
8.	P2MATE308	Advanced Topology	4+1	6.5	32.5	Elective	Theory		Global						
9.	P2MATE309	Advanced Measure Theory	4+1	6.5	32.5	Elective	Theory		Global						
10.	P2MATE310	Differential Geometry	4+1	6.5	32.5	Elective	Theory		Global						
11.	P2MATE311	Dynamical System and Controls	4+1	6.5	32.5	Elective	Theory		Global						
12.	P2MATE312	Mathematical Modelling	4+1	6.5	32.5	Elective	Theory		Global						
13.	P2MAM0351	SAWYAM/MOOC Course	4	6.5	26	Elective	Theory		Global				SAWYAM		

Two Years Postgraduate Programme in Mathematics (4th Semester)

S. No	Course No/Code	Course Title	No of Credits			Course Type	Marks		Nature of Course				SAWYAM/MOOC	Vocational Course	Research Project/Summer Internship/Dissertation
				Credits Level	Credits Points	Core Elective/ Any Other	Theory	Practical/ Tutorial	Global	National	Regional	Skill			
1.	P2MATE401	Topological Vector Spaces	4+1	6.5	32.5	Elective	Theory		Global						
2.	P2MATE402	Harmonic Mappings	4+1	6.5	32.5	Elective	Theory		Global						
3.	P2MATE403	Uniform Spaces and Function Spaces	4+1	6.5	32.5	Elective	Theory		Global						
4.	P2MATE404	Nevanlinna Value Distribution Theory	4+1	6.5	32.5	Elective	Theory		Global						
5.	P2MATE405	Several Complex Variables	4+1	6.5	32.5	Elective	Theory		Global						
6.	P2MATE406	Advanced Optimization Techniques	4+1	6.5	32.5	Elective	Theory		Global						
7.	P2MATE407	Operator Theory	4+1	6.5	32.5	Elective	Theory		Global						
8.	P2MATE408	Advanced Numerical Techniques	4+1	6.5	32.5	Elective	Theory		Global						
9.	P2MARC409	Research Thesis/Project/Patent	16	6.5	104	Core	Theory		Global						Research

Syllabi and Course of Study of Two Years Postgraduate Programme in Mathematics
(NEP 2020)
University of Jammu.

SEMESTER I
(Examination to be held in December 2025, 2026, 2027)

Course Code: P2MATC101 **Course Title: Ordinary and Partial Differential Equations**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 400**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: The objective of this course is to make the students understand the physical world mathematically besides preparing to do analysis at higher levels. A large number of physical phenomena occurring in Physics, Engineering Sciences, Elascitity's Mechanics, etc. when formulated mathematically give rise to mathematical model in the form of Ordinary and Partial Differential Equations with boundary conditions. So, solving a physical situation is equivalent to solving a Ordinary and Partial Differential Equations.

Course Outcomes; This course shall enable students to

1. find solutions of ordinary differential equations using existence and uniqueness theorem, Picard's approximation method, reduction of order, variation of parameter and so on.
2. learn about power series solution of differential equations about ordinary points. Important properties of Legendre polynomials like their orthogonality and eigen values shall be made aware to the students. Moreover, students shall be able to understand and solve problems related to special functions like Bessel's functions and Gauss hypergeometric functions.
3. understand the existence and basic properties of Laplace transform, inverse Laplace transform, the idea of convolution and their applications in solving linear differential equation with constant coefficients. Students shall also be able to construct Green's function for various differential operators.
4. understand Partial Differential Equation of 2nd and Higher order, classification examples of Partial Differential Equations, Partial Differential Equations relevant to industrial problems, Solutions of elliptic, hyperbolic and parabolic equations.
5. understand Transport Equation: Initial value Problem, Non homogeneous Equation. Laplace equation-Fundamental solution Mean Value Formulas, Properties of Harmonic functions, Green's Function, Energy methods .
6. understand Heat Equation: Fundamental solution, Mean Value Formulas, Properties of solutions, Energy Methods, Wave Equation: Solution by Spherical means, Non-Homogeneous equation.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Power series solutions about ordinary points, definitions and existence theorem, solutions of Legender equation, Legender polynomials, generating function, Rodrigues formula, and orthogonality property of Legender's polynomials. Power series solutions about singular points- the method of Frobenius, definition, existence theorem, the method of Frobenius, solutiuons of Bessel's equations, Bessel's functions and their properties. Gauss hypergeometric differential equations and functions defined by them with some important properties- Chebyshev polnomials and minimax property, Riemann's equations- the generalized Gauss hypergeometric equations. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Laplace transform: Definition, Existence and Basic properties of Laplace transform, the Inverse Laplace transform and the convolution, applications of Laplace transform to linear differential equations with constant coefficients, Sturm- Liouville boundary value problems: Definitions and examples, characteristic values and characteristic functions, and orthogonality of characteristic functions.Green's function: Concept of Green's function, properties of Green's function, Construction of Green's function for various differential operators, and idea of Dirac- delta function. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Partial Differential Equation of 2nd and Higher order, classification examples of Partial Differential Equations, Partial Differential Equations relevant to industrial problems, Solutions of elliptic, hyperbolic and parabolic equations. Laplace equation-Fundamental solution Mean Value Formulas, Properties of Harmonic functions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Heat Equation: Fundamental solution, Mean Value Formulas, Properties of solutions, Energy Methods, Wave Equation: Solution by Spherical means, Non-Homogeneous equations. Separation of variables, Fourier and Laplace transform and their applications to solve initial and boundary value problems. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. S.L. Ross: Differential Equations, 3rd Edition, John Wiley and Sons (Asia) Pvt. Ltd. 2004 (for unit I and II).
2. I. N. Sneddon, *Partial Differential Equations*, McGraw Hill (for unit III and IV).

Reference Books:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw- Hill 2003.
2. W. E. Boyce, and R.C.DiPrima, Elementary Differential Equations and Boundary value Problems, John Wiley and Sons, 1977.
3. E. A. Coddignton, An Introduction to Ordinary Differential Equation, Prentice Hall of India Pvt. Ltd., New Delhi 2005.
4. F.G. Roach, Green's Function, Von Nostrand, 1970.
5. L. C. Evans, *Partial Differential Equations,* Graduate studies in mathematics, Vol.19, AMS-1998.
6. T. Amarnath, *Partial Differential Equations,* Prentice Hall.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

Practical/Research(thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the examination**	**% Weightage (Marks)**		
Mid Term appraisal	4 hours	25 %		
External Examination	4 hours	75 %	50 %	Project Report
			25 %	Viva-voce
Total		100		

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study of Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER I

(Examination to be held in December 2025, 2026, 2027)

Course Code: P2MATC102 Course Title: Calculus of Functions of Several Variables
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) Level- 400
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives:

1. Build a deep and intuitive understanding of functions of several variables-geometry of $\mathbb{R}^n$, vector- and scalar-valued mappings, and the fundamental theorems of vector calculus.
2. Equip students to formulate and solve real-world problems involving directional derivatives, multiple integrals, line and surface integrals, and applications of Stokes' and Gauss' Divergence theorems.
3. Foster the ability to read and construct clear mathematical arguments -proofs of mean value, inverse mapping, and open mapping theorems etc-thus strengthening abstract reasoning.
4. To promote independent learning and collaborative problem-solving skills through tutorial sessions, assignments, and project-based exercises in alignment with experiential learning goals of NEP 2020.

Course Learning Outcomes: After successfully completing this course, students will be able to:

1. Geometric Foundations: Describe and manipulate points, vectors, norms, distances, angles (dot and cross products), and parametrized curves and surfaces in $\mathbb{R}^n$.
2. Multivariable Differentiation: Compute and interpret limits, partial and directional derivatives, gradients, and best affine (linear) approximations, and use them to derive tangent lines and planes.
3. Multiple Integration: Set up and evaluate double and triple integrals in Cartesian and transformed coordinates (polar, cylindrical, spherical), including change-of-variable via the Jacobian.
4. Vector Calculus and Integral Theorems: Formulate and compute line and surface integrals of scalar and vector fields, and apply Green's, Stokes', and Guass' Divergence theorems to relate integrals over curves, surfaces, and volumes.
5. Optimization and Applications: Locate and classify extrema (including constrained extrema via Lagrange multipliers) of functions of several variables, and model real-world phenomena in physics and engineering (e.g., work, flux, fluid flow) using the tools of multivariable calculus.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Geometry of multidimensional spaces: introduction to $\mathbb{R}^n$, vectors, norms, and distance; angles and the dot product; the cross product in $\mathbb{R}^3$; lines, planes, and hyperplanes; linear and affine functions; operations with matrices.
Functions from $\mathbb{R}$ to $\mathbb{R}^n$: curves in space, best affine approximations to curves, motion along a curve, arc length, and speed. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Functions from $\mathbb{R}^n$ to $\mathbb{R}$: geometry of graphs and level sets, limits and continuity, directional derivatives and the gradient, best affine approximations: differentiability, second-order approximations: Hessians and Taylor's formula, extreme values and Lagrange multipliers, definite integrals over regions in $\mathbb{R}^n$, change of variables in multiple integrals. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Functions from $\mathbb{R}^m$ to $\mathbb{R}^n$ and applications: geometry of functions between Euclidean spaces, limits and continuity in higher dimensions, best affine approximations for vector-valued functions, line integrals, Green's theorem (for rectangles and for regions of type III). Applications to physics and engineering, examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Directional derivative, mean value theorem, the contraction principle, the inverse function theorem, open mapping theorem.

Surface integrals: definition of double (resp. triple) integral of a function defined and bounded on a rectangle (resp. box), parametrized surfaces, smooth patches, equivalent reparametrizations, surface-area element, surface integrals of scalar and vector fields, curl and divergence, Stokes' theorem (proof assuming the general form of Green's theorem), Gauss divergence theorem (proof only in the case of cubical domains), and their applications. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. Dan Sloughter, *The Calculus of Functions of Several Variables*, Furman University, 2001.
2. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill, New York 1976.
3. T. M. Apostol, Calculus, Vol. II: Multi-Variable Analysis, John Wiley & Sons, New York 2002.

Reference Books:

1. J. E. Marsden and A. J. Tromba, *Vector Calculus*, W. H. Freeman, New York 2003.
2. H. M. Schey, *Div, Grad, Curl, and All That: An Informal Text on Vector Calculus*, W. W. Norton, New York 2005.
3. M. Spivak, *Calculus on Manifolds: A Modern Approach to Classical Theorems of Advanced Calculus*, Westview Press, Boulder, CO 2005.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	Syllabus to be covered in the examination	Time allotted for the examination	% Weightage (Marks)
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
<tr><th colspan="5">Practical/Research(thesis/project/dissertation)</th></tr>
<tr><th>MCQ on LMS + Subjective Test</th><th>Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
<tr><td>Mid Term appraisal</td><td>4 hours</td><td colspan="3">25 %</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
<tr><td>25 %</td><td>Viva-voce</td></tr>
<tr><td colspan="2">Total</td><td colspan="3">100</td></tr>
</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER I

(Examination to be held in December 2025, 2026, 2027)

Course Code: P2MATC103 **Course Title: Topology**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 400**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Course Objectives: The syllabus aims to familiarize students with the essential concepts and techniques in metric and topological spaces. The study of metric and topological spaces is essential for developing proficiency in abstract mathematical concepts. The theory of metric and topological spaces extends from the concept of distance, providing a foundation for understanding advanced topics like Analysis, Measure Theory, and Complex Analysis. This subject helps students recognize that metric spaces are more general than Euclidean spaces, enabling them to work with continuous functions and various important concepts such as connectedness, compactness, and completeness. These concepts enhance mathematical reasoning and problem-solving skills, allowing students to apply them in various contexts. Through problems and exercises, students develop analytical and critical thinking abilities, preparing them for further mathematical study and research.

Course Outcomes: After studying this course, the student will be able to

1. understand the fundamental concepts in the set theory like, cardinality, Zorn's lemma, Hausdroff maximality principle and so on.
2. understand how the theory and concepts grow naturally from idea of distance; and differentiate between functions that define a metric on a set and those that do not.
3. determine interior, closure, limit points of subsets and basis and subbasis of topological spaces.
4. check whether a collection of subsets is a basis for a given topological spaces or not, and determine the topology generated by a given basis.
5. identify the continuous maps between two spaces and determine common topological property of given two spaces.
6. determine the connectedness, path connectedness and components of spaces and understand the concept of compactness in the product of spaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Cardinal numbers, the Schröder-Bernstein Theorem, cardinal number of power set, Cantor's Theorem, the continuum hypothesis. Axioms of Choice, Hausdorff Maximality Principle, Zorn's Lemma, the well-ordering principle. Metric on a set, open and closed balls, limit point and closure, open and closed sets, bounded sets, dense sets, Cauchy and convergent sequences, completeness, continuity, isometry. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Topological Spaces, basis and subbasis for a topology, product topology, subspace topology, closed sets and limit points, closure and interior sets, convergence of sequences, T_1-space and Hausdorff space. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Continuous functions, homeomorphisms, the pasting lemma, product topology, box topology and their relationships. Metric topology, metrizable space, first countability, the sequence lemma, Uniform limit theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Connectedness, components and local connectedness, compact spaces, compact subspaces, tube lemma, finite product of compact spaces, finite intersection property, Lebesgue number lemma, uniform continuity theorem, Bolzano-Weierstrass property (BWP), sequentially and countably compactness. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. T Lin and You-Feng Line, Set Theory, Houghton Mifflin Company Boston, 1974 (for Unit-I).
2. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, 2005 (for Unit-I).
3. J. R. Munkres, Topology, Pearson Education India, 2013 (for Unit-II, III & IV).
4. Patty C.W., Foundation in General Topology, Jones and Bartlett, 2010.

Reference Books:

1. H. B. Ederton, Elements of Set Theory, Academic Press, 1977.
2. P. R. Halmos, Naive Set Theory, East-West Press, 1960.
3. Micheál Ó Searcóid, Metric Spaces, Springer-Verlag London, 2007.
4. R. Magnus, Metric Spaces, Springer Nature Switzerland AG, 2022.
5. S. Willard, General Topology, Addison Wesley, 1970.
6. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Education, 1963.
7. J. L. Kelley, General Topology, Springer Science & Business Media, 1975.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

Practical/Research(thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the examination**	**% Weightage (Marks)**		
Mid Term appraisal	4 hours	25 %		
External Examination	4 hours	75 %	50 %	Project Report
			25 %	Viva-voce
Total		100		

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics
(NEP 2020)
University of Jammu.

SEMESTER I

(Examination to be held in December 2025, 2026, 2027)

Course Code: P2MATC104 **Course Title: Number Theory and Cryptography**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 400**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course helps the students to learn and master the basics of number theory so as to develop skills and knowledge of standard concepts ready to be applied to cryptography and demonstrate how cryptography plays an important role in the present digital world by knowing encryption and decryption techniques and secure data in transit across data networks.

Course Learning Outcomes: After studying this course the student will be able to

1. Explain fundamental concepts of number theory and cryptography, including Farey sequences, continued fractions, Pell's equations, divisibility, modular arithmetic, and classical theorems (Fermat's, Euler's, Chinese Remainder Theorem).
2. Apply classical and modern encryption techniques such as Caesar cipher, Playfair cipher, substitution and transposition ciphers, block cipher structures, Data Encryption Standard (DES), and Advanced Encryption Standard (AES).
3. Utilize finite field arithmetic in $GF(2^n)$ and $GF(p)$ for implementing cryptographic algorithms including AES and elliptic curve cryptography, and analyze their roles in cryptosystems.
4. Implement and evaluate public-key cryptosystems such as RSA and elliptic curve cryptography for encryption, decryption, key generation, and digital signatures, and assess their security.
5. Describe cryptographic hash functions, digital signature schemes, and apply cryptographic solutions to ensure security in email communication, wireless networks, and mobile devices.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Farey sequences, infinite continued fractions, irrational numbers, approximations to irrational numbers, best-possible approximations, divisibility of Integers, Greatest common divisor, Euclidean algorithm. The theorem of arithmetic, Congruences, Residue classes and reduced residue classes. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, Euler's theorem, Arithmetic functions $\sigma(n)$, $d(n)$, $\tau(n)$, $\mu(n)$, Möbius inversion formula, order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Introduction to cryptography & cryptosystem: definitions, the Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, Hill Cipher, Permutation Cipher, Stream Cipher. Cryptanalysis of Affine Cipher, Cryptanalysis of Substitution Cipher, Cryptanalysis of Vigenere Cipher, Cryptanalysis of Hill Cipher. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Linear Cryptanalysis, Differential Cryptanalysis, Basic Encryption and Decryption, Encryption Techniques, characteristics of Good Encryption Systems, International Data Encryption Algorithm, Shannon's Theory: Elementary probability theory, perfect secrecy, Entropy, properties of Entropy, Product cryptosystems. principles of public-key cryptosystems, RSA-key generation, RSA-encryption & decryption, RSA-security & common attacks, Elliptic-curve arithmetic over GF(p). Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. David, M. Burton, *Elementary Number Theory*, 2nd Edition (UBS Publishers).
2. D. R. Stinson, *Cryptography: Theory and Practice*, CRC Press, 1995.
3. W. Stallings: *Cryptography and Network Security, Principles and Practice (7th ed.)*, Pearson Education Limited, England, 2017.
4. W. Trappe, and L. C. Washington: *Introduction to Cryptography with Coding Theory (2nd ed.)*, Pearson Education International, 2006.

Reference Books:

1. I. M. Niven, H. S. Zuckerman, and H. L. Montgomery, *Introduction to Theory of Numbers*, 5th Edition, John Wiley and Sons, 1960.
2. H. Davenport, *Higher Arithmetic*, Camb. Univ. Press, 2008.
3. G. H. Hardy and E. M. Wright, *An Introduction To The Theory Of Numbers*, Oxford Univ. Press, 2008.
4. N. Koblitz , *A Course in Number Theory and Cryptography, Graduate Texts in Mathematics*, New-York: Springer-Verlag, 1987.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

Practical/Research(thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the examination**	**% Weightage (Marks)**		
Mid Term appraisal	4 hours	25 %		
External Examination	4 hours	75 %	50 %	Project Report
			25 %	Viva-voce
Total		100		

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

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SEMESTER II
(Examination to be held in May 2026, 2027, 2028)

Course Code: P2MATC201 **Course Title: Advanced Complex Analysis**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims at introducing students to characterization of harmonic functions, Monodromy Theorem, Riemann Mapping Theorem, the theorems of Montel and Picard and those of Mittag-Leffer and Weierstrass, and the Prime Number Theorem.

Course Learning Outcomes: After studying this course the student will be able to

1. understand the basics of logarithmically convex function that helps in extending maximum modulus theorem.
2. be familiar with metric on spaces of analytic, meromorphic and analytic functions, Ascoli and related theorems, equi-continuity and normal families leading to Arzela.
3. know harmonic function theory on a disk and how it helps in solving Dirichletâs problem and the notion of Greenâs function.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Harmonic Functions: Harmonic Conjugates, necessary and sufficient condition for the existence of harmonic conjugates, mean value property, Gauss Mean Value Theorem, Poisson Integral Formula, Dirichlet Problem on the open disk, characterization of harmonic functions, Schwarz Reflection Principle, analytic continuation, Monodromy Theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Equicontinuous families of continuous functions, Arzela-Ascoli Theorem, normal subfamilies of continuous functions, Montel's Theorem, Riemann Mapping Theorem, The Schwarz-Christoffel Formula. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Normal families of meromorphic functions: Spherical derivative, Marty's Theorem, Zalcman's Lemma, Montel's Three value Theorem, Picard's Theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Runge's Theorem, the series of meromorphic functions, constructing meromorphic function: the Mittag-Leffer Theorem, the Weierstrass $\wp-$function, infinite products, infinite products of functions, infinite products and analytic functions, the Weierstrass Factorization Theorem and its consequences.The Gamma function, the Riemann $\zeta-$ function and their properties, the Prime Number Theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books: The following Text Books need to be consulted simultaneously:

1. Theodore W. Gamelin, Complex Analysis, Springer-Verlag, 2001.
2. Bruce P. Palka, An Introduction to Complex Function Theory, Springer+Business Media, 1991.

Reference Books:

1. Lars V. Ahlfors, Complex Analysis, McGraw-Hill International Editions, 1979.
2. John B. Conway, Functions of One Complex Variable, Narosa Publishing House, 1990.
3. S. Ponnusamy and Herb Silverman, Complex Variables with Applications, Birkhauser, 2006.
4. Serge Lvovski, Principles of Complex Analysis, Springer, 2020.
5. Reinhold Remmert, Theory of Complex Functions, Springer, 1991.
6. Steven G. Krantz, Complex Variables, Chapman and Hall/CRC, 2008.
7. Joseph L. Taylor, Complex Variables, American Math. Soc., 2011.
8. Elias M. Stein and Rami Shakarchi, Complex Analysis, Princeton University Press, 2003.
9. Zeev Nihari, Conformal Mappings, Dover Publications Inc. New York, 1975.
10. Robert B. Ash and W. P. Woringer, Complex Analysis, Dover Publications, 2007.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
<tr><th colspan="5">Practical/Research(thesis/project/dissertation)</th></tr>
<tr><th>MCQ on LMS + Subjective Test</th><th>Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
<tr><td>Mid Term appraisal</td><td>4 hours</td><td colspan="3">25 %</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
<tr><td>25 %</td><td>Viva-voce</td></tr>
<tr><td colspan="2">Total</td><td colspan="3">100</td></tr>
</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

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SEMESTER II

(Examination to be held in May 2026, 2027, 2028)

Course Code: P2MATC202 **Course Title: Functional Analysis**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims at familiarizing the students with the geometry of metric spaces, Banach Spaces and Hilbert spaces. Some fundamental theorems in functional analysis like Banach contraction Principle, Hahn-Banach Theorem, uniform boundedness principle are included in the syllabus. These theorems have immense applications in several branches of Mathematics and Mathematical physics.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Banach contraction Principle and its applications to differential and integral equations, completion theorem, category theorem and its applications.
2. understand Hahn-Banach Theorem in real, Complex and linear spaces and applications, uniform boundedness principle, open mapping theorem, Bounded inverse-theorem, closed graph theorem.
3. understand the existence of orthonormal basis, Riesz representation theorem, the dimension of Hilbert spaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Definition of metric spaces, convergence complete metric spaces, Banach contraction Principle and its applications to differential and integral equations, completion theorem, category theorem and its applications, compactness , Arzela-Ascoli's Theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Normed linear spaces and Banach spaces, examples, finite dimensional normed linear spaces, equivalent norms quotient spaces, F. Riesz's lemma , Bounded linear operators, examples, dual spaces, computation of duals of IR, $l_p, 1 \leq p < \infty$ and C_0. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Hahn-Banach Theorem in real, Complex and linear spaces and applications, reflexive spaces, uniform boundedness principle, open mapping theorem, Bounded inverse-theorem, closed graph theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Inner product spaces, the Cauchy-Schwartz inequality, the Phythagorean Theorem, Hilbert spaces, examples of Hilbert spaces. Orthognal complement and direct sum, minimizing vector theorem, projection theorem, orthonormal sets, Bessel's inequality orthonormal basis, the existence of orthonormal basis Riez representation theorem, the dimension of Hilbert spaces. Adjoint of a linear operator, self adjoint, normal and unitary operators. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. C. Goffman and G. Padrick, *First course in Functional Hall Analysis*, Prentice 1955.(for unit -1).
2. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley and Sons 1978. (For unit- II, III and IV)

Reference Books:

1. R. G. Douglas, *Banach Algebra Techniques in operator Theory*, Springer-Verlag, New York 1998.
2. J. B. Conway, *A course in Functional Analysis*, Springer Verlag, 1973.
3. B. V. Limaye, *Functional Analysis*, Wiley Eastern Ltd. 1981.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

<table>
<tr><th>MCQ on LMS + Subjective Test</th><th colspan="2">Syllabus to be covered in the examination</th><th>Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
<tr><td>Test-I (after 30 days)</td><td colspan="2">25 %</td><td>1 hour</td><td colspan="3">10+10</td></tr>
<tr><td>Test-II (after 60 days)</td><td colspan="2">26 to 50%</td><td>1 hour</td><td colspan="3">10+10</td></tr>
<tr><th>Theory</th><th colspan="2">Syllabus to be covered in the examination</th><th>Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
<tr><td>Major test (after 90 days)</td><td colspan="2">100 %</td><td>$2\frac{1}{2}$ hour</td><td colspan="3">60</td></tr>
<tr><td colspan="4">Total</td><td colspan="3">100</td></tr>
<tr><th colspan="7">Practical/Research(thesis/project/dissertation)</th></tr>
<tr><th colspan="2">MCQ on LMS + Subjective Test</th><th colspan="2">Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
<tr><td colspan="2">Mid Term appraisal</td><td colspan="2">4 hours</td><td colspan="3">25 %</td></tr>
<tr><td colspan="2" rowspan="2">External Examination</td><td colspan="2" rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
<tr><td>25 %</td><td>Viva-voce</td></tr>
<tr><td colspan="4">Total</td><td colspan="3">100</td></tr>
</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

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SEMESTER II

(Examination to be held in May 2026, 2027, 2028)

Course Code: P2MATC203 **Course Title: Measure Theory**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: The main purpose of this course is to study general theory of measure integration. The theory of measures has its origin in the idea of length, area and volume in Euclidean spaces. It has a lot of application in functional theory and several branches of Physics.

Course Outcomes: After studying this course the student shall be able to

1. learn about measurable and measure spaces, types of measure and how to construct an outer measure. Also, students shall be able to check whether a given set or a function is measurable.
2. understand the requirement and the concepts of Lebesgue integral (a generalization of the Riemann integration) along its properties.
3. distinguish and understand relationships among uniform convergence, convergence a.e., almost uniform convergence and convergence in mean.
4. demonstrate understanding of the statement and proofs of the fundamental integral convergence theorems like Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem and their applications.
5. extend the concept of outer measure in an abstract space and integration with respect to a measure.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

$\sigma-$algebra of sets, limits of sequences of sets. Generation of algebras, Borel $\sigma-$algebra, G_δ and F_σ sets. Measure on $\sigma-$algebra, Measures of sequences of sets, Measurable spaces and measure space. Outer measures, regular outer measure, metric outer measure, construction of outer measure. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Lebesgue outer measure on R, properties of Lebesgue measure spaces, translation invariances of Lebesgue measure. Existence of non-Lebesgue measurable sets. Regularity of Lebesgue outer measure. Cantor ternary set and cantor function. Relation between Lebesgue and Borel measurability, completion of measure space. Completion of Borel measure space to the Lebesgue measure space. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Measurable functions, Operation with measurable function, equality a.e., Sequence of measurable functions, continuity and Borel Lebesgue measurability of functions on $\mathbb{R}$, integration of simple functions, Lebesgue integral of non-negative and measurable functions. Properties of Lebesgue integrals. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Convergence a.e., Almost uniform convergence, Egroff's theorem, convergence in measure, convergence in mean, Cauchy sequence in measure, relation among various convergence types. Fatou's lemma, Lebesgue monotone convergence theorem. Lebesgue dominated theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. J. Yeh : Lectures on Real Analysis, World Scientific, 2000.

Reference Books:

1. M.E. Munroe : An Integration 2nd ed. Addison Wesley, 1971.
2. G.D. Barra : Measure Theory and Integration, Willey Eastern 1987.
3. H.L. Royden : Real Analysis, 3rd edition, Macmilon, New York 1988.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

Practical/Research(thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the examination**	**% Weightage (Marks)**		
Mid Term appraisal	4 hours	25 %		
External Examination	4 hours	75 %	50 %	Project Report
			25 %	Viva-voce
Total		100		

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

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SEMESTER II

(Examination to be held in May 2026, 2027, 2028)

Course Code: P2MATC204 **Course Title: Discrete Mathematics**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 400**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims at introducing students to the Discrete Mathematics course to build a strong foundation in mathematical reasoning, problem-solving, and the application of discrete concepts to various fields, particularly computer science. Students learn to use mathematical logic, work with sets and functions, explore combinatorics, understand graph theory and Boolean algebra. The course also aims to develop skills in proving mathematical statements and using inductive arguments.

Course Learning Outcome: After doing this course, the students are expected to have built a strong foundation in mathematical reasoning, problem-solving, and the application of discrete concepts to various fields, particularly computer science. Students are expected to have learnt to use mathematical logic, work with sets and functions, explore combinatorics, understand graph theory and Boolean algebra.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Set theory of strings, finite state machines, Computer recoginition:zero-one matrices and directed graphs, partial order relations: Hasse diagrams, Equivalence relations and partitions, Finite state machines: the minimization process. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Principle of inclusion and exclusion,generalizations of the principle,dearrangements, Rook's polynomials, arrangements with forbiden positions, Generating functions, partitions of integers, exponential generating functions, the summation operator, recurrence relations. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Introduction to Graph Theory: Definition and examples, subgraphs, components, graph isomorphisms, Euler trails and circuits, planar graphs, Hamiltonian paths and circuits, graph coloring and chromatic polynomials. Trees: Definitions, examples and properties, rooted trees, trees and sorting. Dijkstra's Shortest-path Algorithm, the Alogorithms of Kruskal and Prim, the Max-Flow Min-cut theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Boolean Algebra and Switching Functions: Disjunctive and conjunctive normal forms, Gating networks, minimal sums of products, Karnaugh maps, the structure of Boolean algebra. Examples and exercises based on these concepts will be covered in the tutorials.

Text Book:

1. Ralph P. Grimaldi, Discrete and Combinatorial Mathematics, Pearson Education, 2006.
2. Kenneth H., Rosen, Discrete Mathematics and its Applications, Mc Graw Hill Education, 2019.

Reference Books:

1. Kenneth H., Rosen, Discrete Mathematics and its Applications, Mc Graw Hill Education, 2019.
2. Joe L. Mott, Abraham Kandel and Theodore P. Baker, Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall of India Pvt. Ltd., 2008.
3. David J. Hunter, Essentials of Discrete Mathematics, Jonnes and Bartlett Learning, 2017.
4. Chung L. Liu, Elements of Discrete Mathematics, Mc Graw Hill Inc., 1985.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
<tr><th colspan="5">Practical/Research(thesis/project/dissertation)</th></tr>
<tr><th>MCQ on LMS + Subjective Test</th><th>Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
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<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
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</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

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SEMESTER II

(Examination to be held in May 2026, 2027, 2028)

Course Code: P2MATC205 **Course Title: Research Methodology and Research & Publication Ethics**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 400**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: The objective of this course is to introduce students to the fundamentals of the research process in mathematics, including research design, problem formulation, and literature review. It aims to develop skills in using tools like LaTeX, MATLAB, and Mathematica for scientific writing and computation. The course also focuses on ethical research practices and understanding quality standards in academic publishing. Students will be guided in preparing research papers, presentations, and bibliographies effectively.

Course Learning Outcomes: After studying this course the student will be able to

1. Understand the fundamental concepts and significance of research, including various methodologies and design principles.
2. Conduct a comprehensive literature survey using tools such as MathSciNet, JSTOR, IEEE, and other open-access or subscribed databases.
3. Utilize LaTeX, MATLAB, and Mathematica for writing, calculating, and visualizing mathematical content effectively.
4. Identify and formulate research problems through critical analysis of literature and application of creative thinking techniques.
5. Demonstrate knowledge of research ethics and quality standards, and develop skills to write and present well-structured research papers and reports.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Overview of research process: Meaning of research, various approaches of re search significance of research, enters of good research, developing the objectives, preparing the Research Design Literature survey What is literature survey, Functions of literature survey Searching for Publications Publication databases, search engines and Online tools-Open sources open access journals, other important websites, groups and societies). Subscribed sources IEEE Springer link. Selenge direct, AMS. LMS, JSTOR etc. DELFNET).

Unit-II

Survey papers. Math Sci net, use of scientific workplace, MATLAB/MATHEMATICA for scientific calculations and visualization of data. LaTeX for typesetting-How to write a mathematics document in LaTeX. Understanding the key research area of interest. Conditions and Steps in select ing a research problem.

Unit-III

Sources of research problem: Creative thinking techniques, Study of research gaps, Critical reading of research papers formulating the research problem and writing the synopsis. Method of writing a good research paper, publishing a research paper.

Unit-IV

Ethical issues: Commercialization, Copy Right, Reproduction of published material, Plagiarism, Citation and acknowledgment, Reproducibility and account ability standards of quality (Refereed, indexed, impact factor paper citation Index etc.) Indexing databases (Math sci net, ZB Math, AMS Mathematical Reviews, Scopus etc.), Critical evaluation of standards of quality. Preparing seminar presentation, Preparing research report, Preparing bibliography (various styles).

Reference Books:

1. MATLAB, An Introduction With Applications, Amos Gilat: Wiley India Edition.
2. Hands-On Start to Wolfram Mathematica: Cliff Hastings, Kelvin Mischo, Michael Morrison, Wolfram Media Inc. 2015.
3. More Math into LaTeX (4th Edition); George Gratzer: Springer 2007.
4. Research Methodology, Methods and Techiniques (Third Edition) C. R. Kothari, Gaurav Garg: New Age International Publishers.
5. Research Methodology; Dr. Pramod Kumar Naik, Dr. Pushkar Dubey; APH Publishing Corporation.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

<table>
<tr><th>MCQ on LMS + Subjective Test</th><th>Syllabus to be covered in the examination</th><th>Time allotted for the examination</th><th>% Weightage (Marks)</th></tr>
<tr><td>Test-I (after 30 days)</td><td>25 %</td><td>1 hour</td><td>10+10</td></tr>
<tr><td>Test-II (after 60 days)</td><td>26 to 50%</td><td>1 hour</td><td>10+10</td></tr>
<tr><td>Theory</td><td>Syllabus to be covered in the examination</td><td>Time allotted for the examination</td><td>% Weightage (Marks)</td></tr>
<tr><td>Major test (after 90 days)</td><td>100 %</td><td>$2\frac{1}{2}$ hour</td><td>60</td></tr>
<tr><td colspan="3">Total</td><td>100</td></tr>
</table>

<table>
<tr><th colspan="4">Practical/Research(thesis/project/dissertation)</th></tr>
<tr><th>MCQ on LMS + Subjective Test</th><th>Time allotted for the examination</th><th colspan="2">% Weightage (Marks)</th></tr>
<tr><td>Mid Term appraisal</td><td>4 hours</td><td colspan="2">25 %</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 % Project Report</td></tr>
<tr><td>25 % Viva-voce</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100</td></tr>
</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

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Vocational Course
(Examination to be held in July 2026, 2027, 2028)

Course Code: P2MAVC251 **Course Title: Computational Tools for Mathematics**
Credits: 04 **Level- 400**

Maximum Marks: 100

Course Objectives: This course aims to provide students with foundational knowledge of computers and their applications in mathematics. It introduces basic computer components, data representation, and software tools relevant to mathematical computations and documentation. The course emphasizes the importance of LaTeX for professional mathematical writing, covers essential computational tools like spreadsheets and algorithmic problem-solving, and offers a practical introduction to programming concepts using C and Python for solving mathematical problems. Through this course, students will gain computational proficiency, improve their ability to document mathematical work, and develop basic programming skills applicable to mathematical modeling and research.

Course Outcomes: After studying this course, the student will be able to

1. Explain the basic components of a computer system, data representation formats, operating system functions, and the role of mathematical software.
2. Create professional-quality mathematical documents using LaTeX, including equations, theorems, tables, figures, and bibliographic references.
3. Apply computational tools such as spreadsheets to perform basic mathematical calculations, generate visualizations, and use algorithmic thinking to solve mathematical problems with flowcharts and pseudocode.
4. Write simple programs in C and Python to perform mathematical operations such as solving equations, generating sequences, and carrying out matrix operations.
5. Demonstrate an understanding of how computational tools and programming contribute to mathematical research, modeling, and problem solving.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Introduction to Computers in Mathematics: Historical perspective and modern applications. Basic Computer Components: CPU, memory, input/output devices, storage. Data Representation: Binary, octal, hexadecimal systems. Number conversions and arithmetic relevant to computing. Networks and Operating Systems: Functions, file management, command-line basics (Windows/Linux). Overview of software types: system, application, mathematical softwares like MATLAB, Mathematica-overview only. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Importance of documentation in mathematics. Introduction to LaTeX: document structure, environments, packages. Writing mathematical formulas, equations, and expressions. Creating theorems, lemmas, proofs, and definitions. Tables, figures, citations, and references in LaTeX, Compiling academic-style mathematical documents (assignments, reports, thesis chapters). Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Need for computational tools in mathematics. Overview of spreadsheets (Excel/Google Sheets): simple calculations, formulas, visualizations. Introduction to algorithmic thinking: what is an algorithm, how computers solve mathematical problems. Flowcharts and pseudocode for mathematical processes. Examples: solving systems of equations, iteration, factorials, sequences. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Role of programming in modern mathematics and research. Overview of compilers, interpreters, and IDEs. C Programming Concepts: Data types, variables, operators, control structures (if, loops), functions. Python Programming Concepts: Syntax, variables, math operations, conditional statements, loops, lists. Solve algebraic equations, Generate mathematical sequences, Perform matrix operations and numerical tasks. Examples and exercises based on these concepts will be covered in the tutorials.

Textbook:

1. P.K. Sinha and P. Sinha, *Computer fundamentals*, BPB publications, 2004.
2. Yashavant Kanetkar, *Let us C*, BPB Publications, 2020.
3. Leslie Lamport, *LaTeX: A Document Preparation System*, Addison-Wesley, 2nd Edition, 1994.

Reference Books:

1. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, Prentice Hall, 2nd Edition, 1988.
2. Charles Dierbach, *Introduction to Computer Science Using Python: A Computational Problem-Solving Focus*, Wiley, 1st Edition, 2015.
3. William J. Turkel and Adam Crymble, *Programming Historian: Introduction to LaTeX and Markdown*, The Programming Historian (open educational resource).
4. Timothy A. Davis, *MATLAB Primer*, CRC Press, 8th Edition, 2010.

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SEMESTER III
(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATC301 **Course Title: Field Extensions and Galois Theory**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims to provide a rigorous introduction to extension fields and Galois theory, equipping students with the theoretical foundations necessary to understand algebraic structures underlying field extensions. It emphasizes the study of algebraic, transcendental, and finite extensions, splitting fields, field automorphisms, and the profound connections between field theory and group theory established by Galois theory. The course also seeks to develop problem-solving and proof-writing skills through classical results like the solvability of polynomials, computation of Galois groups, and applications to geometric constructions.

Course Learning Outcomes: After successfully completing this course, students will be able to:

1. Define and work with finite fields, algebraic and transcendental extensions, simple extensions, minimal polynomials, and splitting fields.
2. Apply the tower law and demonstrate understanding of the structure and properties of field extensions.
3. Analyze and determine automorphisms of fields, fixed fields of automorphism groups, and characterize normal and Galois extensions.
4. Compute Galois groups of field extensions and polynomials, and apply the Fundamental Theorem of Galois Theory to establish correspondences between subgroups and intermediate fields.
5. Explain the solvability of polynomials by radicals, including the insolvability of the general quintic, and solve problems involving constructible numbers, classical geometric constructions, and Kronecker constructions.
6. Develop skills in abstract algebraic reasoning, proving theorems, and solving advanced algebraic problems relevant to both theoretical and applied mathematics.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Finite field, extension of a field, degree of an extension, finite, algebraic, and transcendental extensions, simple extensions by adjoining an element, minimal polynomials, the tower law, existence and uniqueness of splitting fields. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Automorphisms of a field, fixed field of a group of automorphisms, normal extensions, Galois extensions, finite fields as Galois extensions of prime fields. Examples and exercises based on these concepts will be covered in the tutorials.

Abod

Unit-III

Galois group of an extension (and of a polynomial), fixed fields, the Fundamental Theorem of Galois Theory, correspondence between subgroups and intermediate fields, examples-quadratic, cyclotomic, and simple radical extensions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Solvability of polynomials by radicals, insolvability of the general quintic, computation of Galois groups (symmetric and cyclic groups), constructible numbers and classical ruler-and-compass constructions, Kronecker construction, rational-root considerations. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. I. N. Herstein, Topics in Algebra, 2nd ed., Lexington Xerox College Publishing, 1975.
2. I. Stewart, Galois Theory, 2nd ed., Chapman and Hall, 1989.

Reference Books:

1. E. Artin, Galois Theory, 2nd ed., Notre Dame University Press, 1966.
2. W. Ledermann, Introduction to Group Theory, Oliver and Boyd, 1973.
3. F. Borceux and G. Janelidze, Galois Theories, Cambridge University Press, 2003.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

Practical/Research(thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the examination**	**% Weightage (Marks)**		
Mid Term appraisal	4 hours	25 %		
External Examination	4 hours	75 %	50 %	Project Report
			25 %	Viva-voce
Total		100		

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

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SEMESTER III

(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATC302 Course Title: Integral Equations and Calculus of Variations
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) Level- 500
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: To introduce the fundamental concepts and methods for solving integral equations and problems in calculus of variations, including Volterra and Fredholm equations, Green's functions, and classical variational problems. The course aims to develop students' analytical skills in applying these techniques to boundary value problems and optimization problems.

Course Learning Outcomes: After successfully completing this course, students will be able to:

1. Formulate and solve Volterra and Fredholm integral equations using resolvent kernels, Neumann series, and Laplace transform methods.
2. Apply Green's function techniques to solve boundary value problems and reduce differential equations to integral equations; further, understand and apply Hilbert-Schmidt theory for symmetric kernels.
3. Solve classical problems in calculus of variations such as shortest distance, brachistochrone, isoperimetric, and geodesics.
4. Derive and use Euler's equation and its generalizations to higher-order and multi-variable functionals.
5. Analyze conditional extremum problems under equality and integral constraints.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Linear Integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series. Laplace transform method for a difference kernel. Solution of a Volterra integral equation of the first kind. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations. Resolvent kernel as a sum of series. Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels. Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homogeneous Fredholm equations with degenerate kernels. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Green function, Use of method of variation of parameters to construct the Green function for a non-homogeneous linear second order boundary value problem, Basic four properties of the Green function, Alternate procedure for construction of the Green function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function, Hilbert-Schmidt theory for symmetric kernels. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Motivating problems of calculus of variations, Shortest distance, Minimum surface of resolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler equation for one dependent function and its generalization to n' dependent functions and to higher order derivatives. Conditional extremum under constraints and under integral constraints. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. Ram P. Kanwal, Linear Integral Equations: Theory and Technique, BirkhÃ□user, 1996.
2. M.D. Raisinghania, Integral Equations and Boundary Value Problems, S. Chand Publishing.
3. I.M. Gelfand and S.V. Fomin, Calculus of Variations, Dover Publications.

Reference Books:

1. Jerri, A.J., Introduction to Integral Equations with applications, A Wiley-Interscience Publication, 1999.
2. A.M. Wazwaz, A First Course in Integral Equations, World Scientific Publishing.
3. F.G. Tricomi, Integral Equations, Dover Publications.
4. L. Elsgolc, Calculus of Variations, Dover Publications.
5. Hilbert and Courant, Methods of Mathematical Physics, Vol. I, Wiley.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
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<tr><td>Mid Term appraisal</td><td>4 hours</td><td colspan="3">25 %</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
<tr><td>25 %</td><td>Viva-voce</td></tr>
<tr><td colspan="2">Total</td><td colspan="3">100</td></tr>
</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

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SEMESTER III

(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATC303 **Course Title: Linear Programming and Optimization Techniques Credits: 05 (Theory: 04 + Practical/Tutorial: 01)** **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims at familiarizing the students with the fundamental concepts, methodologies, and applications of Operations Research (OR). It aims to develop students' ability to formulate, analyze, and solve optimization problems using various OR models.

Course Learning Outcomes: After studying this course, the student will be able to

1. Explain the fundamentals, scope, and methodologies of Operations Research and identify appropriate OR models for decision-making.
2. Formulate and solve Linear Programming Problems using graphical and simplex methods, including special cases.
3. Analyze and apply duality concepts in linear programming and use advanced techniques like the Two-Phase and Big-M methods.
4. Solve transportation and transshipment problems, addressing issues like degeneracy and unbalanced cases.
5. Apply the Hungarian method to assignment problems, including maximization and variations like crew assignment and the travelling salesman problem.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Definition, scope, methodology, and applications of OR. Types of OR models. Concept of optimization. Linear Programming: Introduction, Formulation of a Linear Programming Problem (LPP), Requirements for an LPP, Advantages and limitations of LP. Graphical solution: Multiple, unbounded, and infeasible solutions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Principle of the simplex method: standard form, basic solution, basic feasible solution. Computational Aspect of Simplex Method: Cases of unique feasible solution, no feasible solution, multiple solutions, unbounded solution, and degeneracy. Two Phase and Big-M methods. Duality in LPP, primal-dual relationship. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Introduction to Sensitivity Analysis: Change in coefficients, Interpretation, and economic-significance, Ranges of feasibility. Transportation Problem: Methods for finding a basic feasible solution of a transportation problem. Modified distribution method for finding the optimum solution. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Unbalanced and degenerate transportation problems, transshipment problems, and maximization in a transportation problem. Assignment Problem: Solution by the Hungarian method, Unbalanced assignment problem, Maximization in an assignment problem, Crew assignment, and Travelling salesman problem. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. H. A. Taha, *Operations Research-An Introduction*, Macmillan Publishing Company Inc., 2006. (For Unit I).
2. A. Ravindran, D.T. Phillips, and J.J. Solberg, *Operations Research: Principles and Practice*, 2nd Edition, John Wiley and Sons, 1987. (For Unit II, III, and IV)

Reference Books:

1. F.S. Hiller, and G.J. Liebermann,*Introduction to Operations Research*, Tata McGraw Hill, 2000.
2. K. Swarup, P.K. Gupta, and M. Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi, 2001.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	Syllabus to be covered in the examination	Time allotted for the examination	% Weightage (Marks)
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	2 $\frac{1}{2}$ hour	60
Total			100

<table>
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Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

SEMESTER III
(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE304 Course Title: Fundamentals of Computer in Mathematics
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) Level- 500

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Course Objectives: This course aims to provide students with foundational knowledge of computers and their applications in mathematics. It introduces basic computer components, data representation, and software tools relevant to mathematical computations and documentation. The course emphasizes the importance of LaTeX for professional mathematical writing, covers essential computational tools like spreadsheets and algorithmic problem-solving, and offers a practical introduction to programming concepts using C and Python for solving mathematical problems. Through this course, students will gain computational proficiency, improve their ability to document mathematical work, and develop basic programming skills applicable to mathematical modeling and research.

Course Outcomes: After studying this course, the student will be able to

1. Explain the basic components of a computer system, data representation formats, operating system functions, and the role of mathematical software.
2. Create professional-quality mathematical documents using LaTeX, including equations, theorems, tables, figures, and bibliographic references.
3. Apply computational tools such as spreadsheets to perform basic mathematical calculations, generate visualizations, and use algorithmic thinking to solve mathematical problems with flowcharts and pseudocode.
4. Write simple programs in C and Python to perform mathematical operations such as solving equations, generating sequences, and carrying out matrix operations.
5. Demonstrate an understanding of how computational tools and programming contribute to mathematical research, modeling, and problem solving.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Introduction to Computers in Mathematics: Historical perspective and modern applications. Basic Computer Components: CPU, memory, input/output devices, storage. Data Representation: Binary, octal, hexadecimal systems. Number conversions and arithmetic relevant to computing. Networks and Operating Systems: Functions, file management, command-line basics (Windows/Linux). Overview of software types: system, application, mathematical softwares like MATLAB, Mathematica-overview only. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Importance of documentation in mathematics. Introduction to LaTeX: document structure, environments, packages. Writing mathematical formulas, equations, and expressions, Creating theorems, lemmas, proofs, and definitions, Tables, figures, citations, and references in LaTeX, Compiling academic-style mathematical documents (assignments, reports, thesis chapters). Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Need for computational tools in mathematics. Overview of spreadsheets (Excel/Google Sheets): simple calculations, formulas, visualizations. Introduction to algorithmic thinking: what is an algorithm, how computers solve mathematical problems. Flowcharts and pseudocode for mathematical processes. Examples: solving systems of equations, iteration, factorials, sequences. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Role of programming in modern mathematics and research. Overview of compilers, interpreters, and IDEs. C Programming Concepts: Data types, variables, operators, control structures (if, loops), functions. Python Programming Concepts: Syntax, variables, math operations, conditional statements, loops, lists. Solve algebraic equations, Generate mathematical sequences, Perform matrix operations and numerical tasks. Examples and exercises based on these concepts will be covered in the tutorials.

Textbook:

1. P.K. Sinha and P. Sinha, *Computer fundamentals*, BPB publications, 2004.
2. Yashavant Kanetkar, *Let us C*, BPB Publications, 2020.
3. Leslie Lamport, *LaTeX: A Document Preparation System*, Addison-Wesley, 2nd Edition, 1994.

Reference Books:

1. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, Prentice Hall, 2nd Edition, 1988.
2. Charles Dierbach, *Introduction to Computer Science Using Python: A Computational Problem-Solving Focus*, Wiley, 1st Edition, 2015.
3. William J. Turkel and Adam Crymble, *Programming Historian: Introduction to LaTeX and Markdown*, The Programming Historian (open educational resource).
4. Timothy A. Davis, *MATLAB Primer*, CRC Press, 8th Edition, 2010.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
<tr><th colspan="5">Practical/Research(thesis/project/dissertation)</th></tr>
<tr><th>MCQ on LMS + Subjective Test</th><th>Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
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Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

SEMESTER III

(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE305 **Course Title: Applied Linear Algebra**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course provides students with a rigorous understanding of advanced concepts in linear algebra, combining theoretical foundations with real-world applications. MATLAB will be integrated throughout for computational practice.

Course Outcomes: After studying this course, the student shall be able to

1. Develop an advanced understanding of vector spaces, linear transformations, and matrix theory.
2. Apply eigenvalues, eigenvectors, and spectral decomposition to practical problems.
3. Implement singular value decomposition and principal component analysis for data analysis tasks.
4. Analyze linear systems using Jordan canonical forms and solve optimization problems.
5. Gain computational proficiency with MATLAB for solving complex linear algebra problems.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Vector spaces and subspaces, basis, dimension, and linear transformations. Matrix operations, LU decomposition, and properties of special matrices such as symmetric and positive definite matrices. MATLAB sessions on basic matrix operations, solving systems of equations, and visualizations. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Eigenvalues and eigenvectors, Applications of eigenvalues and eigenvectors, matrix diagonalization, spectral theorem for symmetric matrices, and Schur decomposition. Practical MATLAB exercises on eigendecomposition, system stability analysis, and PageRank algorithm basics. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Singular value decomposition (SVD) and its applications in data science, such as Principal Component Analysis (PCA) and image compression. Least squares, pseudoinverse solutions. MATLAB projects on implementing PCA and compressing images. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Jordan canonical form, stability analysis of linear differential systems, and an introduction to convex optimization and linear programming are covered. MATLAB practice on Jordan decomposition, basic optimization, problem-solving, and system simulations. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. G. Strang, *Linear Algebra and Its Applications*, Cengage Learning, 2005.

Reference Books:

1. D. C. Lay: *Linear Algebra and Its Applications*, Pearson, 2023.
2. S. Boyd and L. Vandenberghe, *Introduction to Applied Linear Algebra- Vectors, Matrices, and Least Squares*, Cambridge University Press, 2018.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
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<tr><td>Mid Term appraisal</td><td>4 hours</td><td colspan="3">25 %</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
<tr><td>25 %</td><td>Viva-voce</td></tr>
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</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

SEMESTER III

(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE306 **Course Title: Geometric Function Theory**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims to provide a solid foundation in geometric function theory, focusing on univalent functions and their subclasses. Topics include the analytic continuation, harmonic functions, and key results like the Area and Distortion theorems. It also covers subordination and coefficient inequalities, preparing students for advanced study in complex analysis.

Course Learning Outcomes: After studying this course, the student will be able to

1. Understand and apply the basic principles of complex analysis, including local mapping properties and analytic continuation.
2. Classify and analyze subclasses of univalent functions such as convex, starlike, and close-to-convex functions.
3. Apply concepts of subordination and coefficient inequalities to solve problems in geometric function theory.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Basic principles, Local mapping properties, Normal families, Extremal problems, The Riemann Mapping Theorem, Analytic continuation, Harmonic and Sub-harmonic functions, Green's functions, Positive Harmonic functions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Univalent Functions: Elementary Properties and results, Examples of univalent functions, Set of univalent functions, Some operations in the set of univalent functions, The Area theorem, Growth and Distortion theorems, Coefficient estimates for univalent functions. Bounded univalent functions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Subclasses of Univalent Functions: Classes of Convex, Starlike and Close-to-convex functions and their properties in the unit disk, Spirallike functions, Typically Real functions, Growth of Integral Means, Odd Univalent functions, Asymptotic Bieberbach Conjecture. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Subordination: Basic principles, Coefficient inequalities: Rogosinski's theorem, Bernstein's theorem, Sharpened form of Schwarz Lemma, Majorization, Univalent subordinate functions. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. Peter Duren: *Univalent Functions*, New York: Springer, 1983.

Reference Books:

1. A. W. Goodman: *Univalent Functions-Volume I & II*, Mariner, Florida, 1983.
2. C. Pommerenke: *Univalent Functions*, Van den Hoek and Ruprecht, Gottingen, 1975.
3. I. Graham, and G. Kohr: *Geometric Function Theory in One and Higher Dimensions*, New York: Marcel Dekker, 2003.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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<tr><td>25 %</td><td>Viva-voce</td></tr>
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</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020)
University of Jammu.

SEMESTER III
(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE307 **Course Title: Complex Dynamics**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims at understanding the dynamical behavior of rational functions.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Iteration of Mobius transformation, attracting, repelling and indifferent fixed points, critical points, Riemann-Hurwitz relation, topology of rational functions.
2. understand Properties of Julia sets: Exceptional points, backward orbit, minimality property of the Julia set, expanding property of the Julia set.
3. understand Rieman Hurwitz formula for covering maps, maps between components of the Fatou set, the number of components of the Fatou set, components of the Julia set.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Iteration of Mobius transformation, attracting, repelling and indifferent fixed points. Iteration of maps $z \to z^2, z \to z^2 + c, z \to z + 1/z$, Newton's approximation. The Extended Complex Plane, chordal metric, spherical metric, rational maps, Lipschitz condition, conjugacy classes of rational maps, valency of a function, fixed points, critical points, Riemann-Hurwitz relation, topology of rational functions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Equicontinuous family of functions, Fatou and Julia sets of a rational map, completely invariant sets, normal families and equicontinuity. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Properties of Julia sets: Exceptional points, backward orbit, minimality property of the Julia set, expanding property of the Julia set, periodic points of a rational map, commuting rational maps and their Julia sets, rational maps with empty Fatou set. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

The structure of the Fatou set: The topology of the sphere, completely invariant components of the Fatou set, the Euler characteristic, the Rieman-Hurwitz formula for covering maps, maps between components of the Fatou set, the number of components of the Fatou set, components of the Julia set. Examples and exercises based on these concepts will be covered in the tutorials.

Text Book:

1. A. F. Beardon, Iteration of Rational Functions, Springer-Verlag, 1991.

Reference Books:

1. L. Carlson and T. W. Gamelin, Complex Dynamics, Springer-Verlag, 1993.
2. N. Steinmetz, Rational Iteration, De Gruyter Studies in Mathematics, 1993.
3. S. Morosawa, Y. Nishimura, M. Taniguchi and T. Ueda, Holomorphic Dynamics, Cambridge University Press, 2000.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

Practical/Research(thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the examination**	**% Weightage (Marks)**		
Mid Term appraisal	4 hours	25 %		
External Examination	4 hours	75 %	50 %	Project Report
			25 %	Viva-voce
Total		100		

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER III

(Examination to be held in December 2025, 2026, 2027)

Course Code: P2MATE308 **Course Title: Advanced Topology**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Course Objectives: Topology serves to lay the foundations to study the Analysis and Geometry. The objective of this course is to introduce and explore advanced topics in topology such as the countability axioms, separation axioms, Urysohn Lemma, the Urysohn Metrization Theorem, the Tietze Extension Theorem, local compactness, one-point compactification, Tychonoff's theorem, Stone-Čech compactification, metrization theorems. The course is designed to develop an understanding of topological ideas & techniques and their role in Analysis. At the end of the course, students should be able to understand and appreciate the central results of general topology, sufficient for the main applications in geometry and analysis.

Course Outcomes: After studying this course, the student will be able to

1. understand about countability and separation axioms, create examples and solve problems related to them.
2. determine how the spaces differ/relate from each other on the basis of countability and separation axioms.
3. find one point compactification of spaces like real line and n-sphere.
4. know interesting results on complete regularity and Stone Cech compactification.
5. have studied celebrated results like Urysohn lemma, Tietze extension theorem, and Baire category theorem. Also, students shall have better understanding of metrization theorems like Urysohn metrization theorem and Nagata Smirnov metrization theorem.
6. check whether the functions can be extended from a subset to the whole space continuously with some particular properties.
7. lean about Baire spaces, m-manifolds and dimension of topological spaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

The countability axioms - first countability, second countability, Lindelöf property, separability their characterizations and basic properties; Separation axioms - T_0, T_1, T_2, T_3, $T_{3\frac{1}{2}}$, T_4, their characterizations and basic properties, concept of nets and basic properties. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Urysohn's lemma, Teitze Extension Theorem, statement of Urysohn's Metrization Theorem, local compactness, one-point compactification, Tychonoff's theorem for arbitrary products, applications of the Tychonoff theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Stone-Čech compactification, local finiteness - locally finite and countably locally finite families, metrizable space, paracompactness and basic properties, metrization theorems: the Nagata-Smirnov metrization theorem and the Smirnov metrization theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Baire spaces, the Baire category theorem, applications of the Baire category theorem, m-manifolds, topological dimension, imbedding theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. J. R. Munkres, Topology, Pearson Education India, 2013.
2. Patty C.W., Foundation in General Topology, Jones and Bartlett, 2010.

Reference Books:

1. S. Willard, General Topology, Addison Wesley, 1970.
2. J. R. Munkres, Topology of Manifolds, Westview Press, 1991.
3. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Education, 1963.
4. G. E. Bredon, Topology and Geometry, Springer, 1993.
5. R. Brown, Topology and Groupoids, BookSurge Publishing, 2005.
6. J. Dugundji, Topology, Allyn and Bacon, 1966.
7. J. L. Kelley, General Topology, Springer Science & Business Media, 1975.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	Syllabus to be covered in the examination	Time allotted for the examination	% Weightage (Marks)
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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<tr><td>25 %</td><td>Viva-voce</td></tr>
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Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER III

(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE309 **Course Title: Advanced Measure Theory**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: The purpose of this paper is to study Borel measures, Riesz-Representation theorem, Differentiation of measure, Radon-Nikodym theorem and Fubini theorem. This is a second course in measure theory and the pre-requisite for this course is basic knowledge of algebra, topology, real and Complex Analysis.

Course Learning Outcomes: After studying this course the student will be able to

1. understand signed measures and complex measures, ability to use Hahn Nikodym theorem and recognized decomposition, Jordan decomposition, Radon singularity of measures.
2. verify conditions under which a measure defined on a semi-algebra or algebra is extendable to a sigma-algebra and to get the extended measure, and to prove the uniqueness up to multiplication by a scalar of Lebesgue measure as a translation invariant Borel measure.
3. to understand the concepts of Baire sets, Baire measures, regularity of measures on Markov representation theorem related to the locally compact spaces, Riesz representation of a bounded linear functional on the space of continuous functions.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

$C_c(X)$ and linear functional on this space. Riesz-representation theorem for positive linear Functional on $C_c(X)$ (only statement). Positive Borel Measures. Regularity properties of Borel measures. Lebesgue measure on IRn and its properties-Lusin's theorem. L_p-spaces, Holder's inequality and Minkowski's inequality. Completeness of L_p- spaces Approximation by continuous functions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Complex measure, Total variation, Absolute continuity, Lebesgue Radon-Nikodym theorem, Consequences of Radon-Nikodym theorem, Positive and negative variations, Hahn decomposition theorem, Bounded linear functional on L_p(only statement), Riesz representation theorem for bounded linear functional on $C_0(X)$ (only statement). Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Derivatives of measure, Symmetric derivative, Maximal function, Lebesgue point, Radon Nikodym derivative in terms of symmetric derivative, Nicely shrinking sets, Lebesgue decomposition of a Complex Borel measure on IRn, Examples and elementary exercises based on these topics. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Measurability on Cartesian products, product measures, Fubini theorem for product measures, Counter examples of Fubini theorem, Completion of product measures, Convolutions. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. Walter Rudin, *Real and Complex analysis*, 3rd edition McGraw. Hill Book Company, 1987.
2. J. Yeh, *Lectures in Real Analysis*, World Scientific 2000.

Reference Books:

1. H. L. Royden, *Real Analysis*, The Mac-Millan Company, New York, 1963.
2. M. E. Munroe, *Measure and Integration*, 2nd edition Addion-Wesley Publishing Company.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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Test I and Test II

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only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics
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SEMESTER III

(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE310 **Course Title: Differential Geometry**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: Being a fundamental course, this course aims at preparing students to realise and do mathematics geometrically by understanding curves, surfaces and geodesics.

Course Outcomes: This course shall enable students to

1. understand the concepts of differentiable curves, arc length, curvature graphs, level sets as solutions of smooth real valued functions vector fields and tangent space.
2. familiarize with the notions of coordinate charts, diffeomorphism, tangent plane and Euler's work on surfaces. Students shall be able to compute angle between curves and area of surfaces.
3. learn about linear self-adjoint Weingarten map and curvature of a plane curve with applications in geometry and physics.
4. know line integrals, be able to deal with differential forms and calculate arc length and curvature of surfaces.
5. deal with parametrization and be familiar with well-known surfaces as equations in multiple variables.
6. study surfaces with boundary, geodesics, minimizing properties of geodesics and be able to understand Gauss Bonnet theorem and its applications.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Curves: Differentiable curves, arc length, parametrization by arc length, plane curves, plane curvature, Directed curvature, Fundamental Theorems for plane curves.
Curves in space: Tangent, normal and binormal unit vectors, curvature and torsion. Oriented Serret frame, Fernet- Serret theorem. Fundamental Theorem for curves in $\mathbb{R}^3$. Properties of curves such as Helix, Bertrand mete, involute, curves on sphere. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Surfaces: A regular surface, examples, coordinate charts, change of coordinate , differentiable functions, diffeomorphism, tangent plane, unit normal vector, oriented surfaces, first fundamental form, element of arc length, invariance of line element under coordinate change, angle between two curves, orthogonal parametrization. Area, curvature for surfaces, Euler's work on surfaces, Principle curvatures, line of curvature. Rodrigue's formula, Gauss map, second fundamental form. Meusnier's theorem, Gaussian curvature, Dupin indicatrix. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Metric Equivalence of Surfaces: Isometry, local isometry, Christoffel symbols, Theorema Egreguem, Gauss equations, Mainardi- Codazzi equations, Statement of Fundamental theorem for regular surfaces, Line of curvature, asymptotic line, special, Geodesic curvature. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Geodesics: Local distance, minimizing properties of geodesics, exponential map, Hopf-Rinow Theorem. Statement of Hopf's Umlaufsatz Theorem, Gauss-Bonnet Theorem, Some applications of Gauss-Bonnet Theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. John McCleary, Geometry From a Differentiable Point of View, Cambridge University Press, 1994.

Reference Books:

1. D.T. Struik, Differential Geometry, Addison Wesley, 1961.
2. Nirmala Parkash, Differential Geometry, Tata MacGraw Hill, Publication Company, New Delhi.
3. W. Klingenberg, A Course in Differential Geometry, Springer-Verlag, New York, 1976.
4. M. Do Carmo: Differential Geometry of Curves and surfaces, Prentice Hall Englewood Cliff's, N.J. 1976.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
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Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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Test I and Test II

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Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER III

(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE311 **Course Title: Dynamical System and Control**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: The aim of this course is to introduce the students to linear and non-linear dynamical systems, control systems, observability, etc. The course may be useful for Ph.D. students also (those who have not studied it at UG/PG level).

Course Learning Outcomes: After pursuing this course, the student shall be able to:

1. Understand the fundamentals of linear and nonlinear systems.
2. Learn the autonomous and nonautonomous system.
3. Analysis of stability theory using phase portraits.
4. Understand the controllability and observability in control theory.
5. Analysis of different types of observer and optimality in control theory.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Introdrction of linear and nonlinear dynamical system, Formulation of physical systems, Existence and uniqueness theorems, Linear systems, Solution of linear systems, Fundamental Matrix-I. Fundamental Matrix-II, Fundamental matrices for non-autonomous systems, Solution of non-homogeneous systems. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Stability of systems: Equilibrium points, Stability of linear autonomous systems, Stability of weakly non-linear systems, Stability of non-linear systems using linearization, Properties of phase portrait, Properties of orbits, Phase portrait: Types of critical points, Phase portrait of linear differential equations-I, Phase portrait of linear differential equations, Poincare Bendixson Theorem, Limit cycle, Lyapunov stability. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Introduction to Control Systems, Controllability of Autonomous Systems, Controllability of Non-autonomous Systems, Observability, Results on Controllability and Observability, Companion Form, Feedback Control. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

State Observer, Stabilizability, Introduction to Discrete Systems, Lyapunov Stability Theory, Optimal Control, Optimal Control for Discrete Systems, Controllability of Discrete Systems, Observability of Discrete Systems, Stability for Discrete Systems, Relation between Continuous and Discrete Systems. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. Nader Jalili and Nicholas W. Candelino, *Dynamic System and Control Engineering*, Cambridge University press.

Reference Books:

1. Braun, M., *Differential Equation and Their Applications*, 4th Edition, Springer 2011.
2. Stephen Barnett, *Introduction to Mathematical Control Theory*, Oxford University Press, 1990.
3. D. Subbaram Naidu, *Optimal Control Systems*, CRC, Press, 2003.
4. M. Gopal, *Modern Control System Theory*, John Wiley & Sons Ltd., 1994.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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Test I and Test II

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Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

SEMESTER III
(Examination to be held in December 2026, 2027, 2028)

Course Code: P2MATE312 **Course Title: Mathematical Modeling**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims to equip students with the foundational principles and practical techniques of mathematical modeling, emphasizing its necessity and broad applicability across disciplines. Students will explore various modeling approaches, including those based on ordinary and partial differential equations, as well as difference equations, to represent and analyze real-world phenomena.

Course Learning Outcomes: After studying this course, the student will be able to

1. Develop and analyze mathematical models using first- and second-order ordinary differential equations.
2. Construct and interpret systems of differential equations for modeling complex interactions in fields like medicine, environmental science, and military conflicts.
3. Apply difference equations and basic theory to model discrete-time processes in probability, finance, population dynamics, and genetics.
4. Formulate and solve mathematical models using partial differential equations.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Mathematical modeling: need, techniques, classification, and illustrative examples; Mathematical modeling through ordinary differential equations of first order; qualitative solutions through sketching. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Mathematical modeling in population dynamics, epidemic spreading, and compartment models; mathematical modeling through systems of ordinary differential equations; mathematical modeling in economics, medicine, and battle. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Mathematical modeling through ordinary differential equations of the second order. Higher order (linear) models. Mathematical modeling through difference equations: Need, basic theory; mathematical modeling in probability theory, economics, finance, population dynamics, and genetics. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Mathematical modeling through partial differential equations: simple models, mass-balance equations, variational principles, probability generating function, traffic flow problems, initial & boundary conditions. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. Frank R. Giordano, Maurice D. Weir, William P. Fox: *A First Course in Mathematical Modeling*, Cengage Learning, 2002.
2. Edward A. Bender: *An Introduction to Mathematical Modeling*, Dover Publications,2003.

Reference Books:

1. J.N. Kapur: *Mathematical Modelling*, New Age International Publishers, Second Edition, 2021.
2. Clive Dym and Elizabeth I. Jane: *Principles of Mathematical Modeling*, Elsevier, 2004.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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Test I and Test II

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Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

SEMESTER IV

(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE401 **Course Title: Topological Vector Spaces**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This is an advanced course in Analysis, An interplay of Algebra, Topology and Analysis is exhibited in this course, A course in Topology, a course in Algebra and a couple of courses in Analysis are pre-requisites for this course.

Course Learning Outcomes: After studying this course the student will be able to

1. understand balanced and absorbing sets, Minkowski functional, normable and metrizable topological vector spaces, complete topological vector spaces and Frechet space.
2. understand Dual spaces, finite dimensional topological vector spaces and Geometric form of Hahn Banach Theorem.
3. understand Duality, Polar, Bipolar theorem, Montel spaces, Schwarz spaces. Quasi completeness inverse limit and inductive limit of locally convex spaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Definitions and examples of vector spaces, convex, balanced and absorbing sets and their properties. Minkowski functional, subspaces, product spaces and quotient spaces of Topological Vector Spaces, locally convex topological vector spaces, normable and metrizable topological vector spaces, complete topological vector spaces and Frechet spaces. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Linear transformations, linear functional and their continuity. Dual spaces, finite dimensional topological vector spaces. Linear Varieties and Hyperplanes. Geometric form of Hahn Banach Theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Uniform boundedness principle. Open mapping theorem and closed graph theorem for Frechet spaces, Banach Analouge theorem, extreme points and external sets Krein- Milman's theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Duality, Polar, Bipolar theorem Barelled and Bornological Spaces Semi Reflexive and Reflexive topological vector spaces. Montel spaces and Schwarz spaces. Quasi completeness inverse limit and inductive limit of locally convex spaces. Distributions. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. Laurent Schwarz, *Functional Analysis*, Courant Institute of Mathematcal Sciences.

Reference Books:

1. R. Larsen, *Functonal Analysis*, Marcel Dekker, 1972
2. F. Treves, *Topological Vector Spaces*, Distributions and Kernels, Academic Press, 1967.
3. G. Grothendick, *Topological Vector Spaces trend*, Gorden and Breach Science Publishers, New York, 1973.
4. G. Kothe, *Topological Vector Spaces-II*, Springer Verlag New York 1976.
5. Walter Rudin, *Functional Analysis*, Tata McGraw Hill, 1973.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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Major Test

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SEMESTER IV

(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE402 **Course Title: Harmonic Mappings**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims to develop a foundational understanding of complex functions and harmonic mappings, with applications to fluid flow, temperature problems, and minimal surfaces. It covers vector fields, univalent harmonic functions, convolution techniques, and the geometric links between harmonic mappings and differential geometry.

Course Learning Outcomes: After studying this course, the student will be able to

1. Understand and work with harmonic univalent functions, including their decomposition and properties.
2. Apply the shearing technique and study convolution and linear combinations of harmonic mappings.
3. Derive and interpret coefficient bounds for subclasses of harmonic univalent functions.
4. Understand the basics of differential geometry and relate harmonic mappings to minimal surfaces through the Weierstrass representation.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Complex Functions and Vector Fields, Complex Potential Functions, Uniform Flows in the Plane and other Regions, Sources and Sinks, Flow in a Channel, Flows in Other Regions, Flows inside the Disk, Interval Sources and Sinks, Steady State Temperature Problems, Flows with Source and Sinks not on the Boundary, Vector Fields with Other Types of Singularities. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Anamorphosis and Mobius Maps, The Class S of Analytic, Normalized, Univalent Functions, Harmonic Univalent functions: Normalizations, Normal families. Decomposition of harmonic mappings into analytic and co-analytic parts. Class of Harmonic Univalent functions: S_H and its properties. The Shearing Technique. Harmonic Koebe function. Properties of the Dilatation and Jacobian. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Subclasses of S_H: Coefficient bounds of Convex, Starlike, and Close-to-convex univalent harmonic mappings and coefficients conjectures. Harmonic Linear Combinations and Convolution: Harmonic Linear Combinations, Univalence of linear combination, and convolution of harmonic mappings. Convolutions of harmonic right half-plane mapping and related results. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Basics of differential geometry and minimal surfaces, Isothermal parameters, Weierstrass representation of minimal surfaces, The Gauss map (G) and height differential (dh). connection of planar harmonic mappings and minimal surfaces. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. M.A. Brillelyper, and M. J. Dorff et. al: *Explorations in complex analysis,* Mathematical Association of America, 2015.

Reference Books:

1. P. Duren: *Harmonic mappings in the plane,* Cambridge University Press, U.K., 2004.
2. I. Graham, and G. Kohr: *Geometric Function Theory in One and Higher Dimensions,* New York: Marcel Dekker, 2003.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

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Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
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Major Test

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Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER IV

(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE403 **Course Title: Uniform Spaces and Function Spaces**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Course Objectives: The objective of this course is to introduce and explore advanced topics in topology such as nets (which are generalizations of sequences) and filters, uniformity and uniformizable spaces, convergence of sequences/nets of functions and corresponding topologies on the function spaces such as topology of pointwise convergence, topology of uniform convergence and topology of uniform convergence on compact, and compact subsets of some topological function spaces. The course is designed to develop an understanding of applications of general topology in function spaces. This course helps students to develop analytical abilities and prepares them for further advanced mathematical study and research.

Course Outcomes: After studying this course, the student will be able to

1. understand about the generalized concepts nets and filters.
2. understand uniformity on a set, uniform spaces and uniformizable topological spaces.
3. know about the different types of function space topologies and corresponding convergences of sequences/nets of functions.
4. know interesting results about topological properties of function spaces.
5. determine how general topology is helpful to understand the structures of function spaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

The concepts of nets and filters, subnets, convergences of nets/filters and basic properties, Uniform spaces - diagonal uniformity, base and subbase for uniformity, examples of uniform spaces, covering uniformity, uniformly connected, uniform continuous functions. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Induced uniformity, uniform embedding, uniform subspaces, product of uniform spaces, topology induced by uniformity and basic properties, topological group as uniform spaces, Cauchy nets, totally boundedness, completeness. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Function spaces: networks of subsets of topological spaces, set-open topologies on the space $C(X)$, particular cases - point-open and compact-open topologies, $C(X)$ as a topological group with set-open topologies, uniform topologies, supremum metric topology. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Maps on function spaces: diagonal, composition, induced, and evaluation maps, splitting topology, conjoining topology, continuous convergence, even and equi-continuity, hyper-Ascoli and hypo-Ascoli topology, dense and compact subsets of function spaces. Examples and exercises based on these concepts will be covered in the tutorials.

Reference Books:

1. I. M. James, Introduction to Uniform Spaces, Cambridge University Press, 1990.
2. I. M. James, Topological and Uniform Spaces, Springer-Verlag Berlin, 1987.
3. R. A. McCoy and I. Ntantu, Topological Properties of Spaces of Continuous Functions, Lecture Notes in Mathematics, Springer-Verlag Berlin, 1988.
4. S. Willard, General Topology, Addison Wesley, 1970.
5. J. R. Munkres, Topology, Pearson Education India, 2013.
6. R. A. McCoy, S. Kundu, V. Jindal, Function Spaces with Uniform, Fine and Graph Topologies, Springer International Publishing AG, Cham, Switzerland, 2018.
7. J. L. Kelley, General Topology, Springer Science & Business Media, 1975.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

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Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020)
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SEMESTER IV
(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE404 **Course Title: Nevalinna Value Distribution Theory**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: The objective of this course is to take the theory of functions beyond holomorphic functions and study the growth of meromorphic functions as introduced by Rolf Nevanlinna in early 1920s.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Poison-Jensen formula, Nevanlinna's first fundamental theorem, the Cartan's identity and convexity theorem, growth of meromorphic functions, order and type of meromorphic functions.
2. understand fundamental inequality, the estimation of the error term S(r), conditions for S(r) to be small, Nevanlinna's theory of deficient values, second fundamental theorem of Nevanlinna.
3. understand Milloux theory: Milluox's basic results, exceptional values of meromorphic functions and their derivatives.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

The Poison-Jensen formula, characteristic function, Nevanlinna's first fundamental theorem, the Cartan's identity and convexity theorem, the Ahlfors-Shimizu characteristic, orders of growth, comparative growth of Nevanlinna's characteristic function $T(r)$ and the logarithm of the maximum modulus $M(r)$. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

The fundamental inequality, the estimation of the error term $S(r)$, conditions for $S(r)$ to be small, Nevanlinna's theory of deficient values and second fundamental theorem of Nevanlinna, some examples. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Deficient functions, functions taking the same values at the same points, fixed points of integral functions, a theorem of Polya: If f and g are integral functions and $\phi = f(g)$ has finite order, then either f is a polynomial or g has zero order. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Milloux theory: Milluox's basic results, exceptional values of meromorphic functions and their derivatives, Tumura-Clunie theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Text Book:

1. W. K. Hayman, Meromorphic Functions, Oxford University Press, 1964.

Ahoo

Reference Books:

1. R. Nevanlinna, Analytic Functions, Springer-Verlag, 1970.
2. Yang Lo, Value Distribution Theory, Springer, 1993.
3. Jianhua Zheng, Value Distribution of Meromorphic Functions, Springer-Verlag, 2010.
4. Ilpo Laine, Nevanlinna Theory and Complex Differential Equations, De Gruyter Studies in Mathematics, 1993.
5. William Cherry and Z. Ye, Nevanlinna Theory of Value Distribution, Springer, 2010.
6. Lee A. Rubel, Entire and Meromorphic Functions, Springer, 1996.
7. Chi-Tai Chuang and C. C. Yang, Fix-points and Factorization of Meromorphic Functions, World Scientific Pub. Co., 1990.
8. A.S.B Holland, Introduction to the Theory of Entire Functions, Academic Press, 1973.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
<tr><th colspan="5">Practical/Research(thesis/project/dissertation)</th></tr>
<tr><th>MCQ on LMS + Subjective Test</th><th>Time allotted for the examination</th><th colspan="3">% Weightage (Marks)</th></tr>
<tr><td>Mid Term appraisal</td><td>4 hours</td><td colspan="3">25 %</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
<tr><td>25 %</td><td>Viva-voce</td></tr>
<tr><td colspan="2">Total</td><td colspan="3">100</td></tr>
</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II

only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

SEMESTER IV

(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE405 **Course Title: Several Complex Variables**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: This course aims at extending Complex Analysis from one variable to several complex variables.

Course Learning Outcomes: After studying this course the student will be able to

1. understand holomorphic functions in several complex variables, Partially holomorphic functions, Cauchy-Riemann differential equations and Cauchy Integral Formula.
2. understand Power series, Taylor series, Laurent series and theoretic interpretation of the Laurent series.
3. understand Riemann Mapping Problem and Cartan's Uniqueness Theorem. Elementary properties of Analytic sets, Riemann Removable Singularity Theorem.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Geometry of $\mathbb{C}^n$, holomorphic functions in several complex variables: definition and basic properties, partially holomorphic functions and the Cauchy-Riemann differential equations, the Cauchy Integral Formula. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

The Space of Holomorphic Functions as a Topological Space: Locally convex spaces, the compact-open topology on the space of continuous mappings on an open set in $\mathbb{C}^n$, and the Theorems of Arzela-Ascoli and Montel. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Power series and Taylor series: Summable families in Banach spaces, Power series, Reinhardt domains and Laurent series. Holomorphic continuation, representation-theoretic interpretation of the Laurent series, Hartogs' Kugelsatz-special case. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Biholomorphic Maps: The Inverse Function Theorem and Implicit Functions. The Riemann Mapping Problem and Cartan's Uniqueness Theorem.
Analytic Sets: Elementary properties of analytic sets, the Riemann Removable Singularity Theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Recommended Books:

1. Volker Scheidemann, Introduction to Complex Analysis in Several Variables, Birkhauser,2005.

2. Paul M. Gautheir, Lectures on Several Complex Variables, Birkhauser, 2014.

3. Klaus Fritzsche and Hans Grauert, From Holomorphic Functions to Complex Manifolds, Springer, 2002.

4. Raghavan Narasimhan, Several Complex variables (Chicago Lectures in Mathematics), The University of Chicago Press, 1971.

5. Raghavan Narasimhan and Yves Nievergelt, Complex Analysis in One Variable (Second Edition), Springer Science + Bussiness Media, New York, 2001.

6. B. A. Fulks, Theory of Analytic Functions of Several Complex Variables, Amer. Math. Soc. 1963.

7. Lars Hormander, An Introduction to Complex Analysis in Several Variables (third Edition), Elsevier, 1988.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

Practical/Research(thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the examination**	**% Weightage (Marks)**		
Mid Term appraisal	4 hours	25 %		
External Examination	4 hours	75 %	50 %	Project Report
			25 %	Viva-voce
Total		100		

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II.** Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER IV

(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE406 **Course Title: Advanced Optimization Techniques**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: To acquaint the students with the concepts of convex and non-convex functions, their properties, various optimality results, techniques to solve nonlinear optimization problems, and their duals over convex and non-convex domains.

Course Learning Outcomes: After studying this course, the student will be able to

1. Analyze elements of queuing systems, classifying different queuing models, and solving problems.
2. Solve deterministic inventory problems, including those involving shortages and price breaks.
3. Apply PERT/CPM techniques for efficient project scheduling and critical path analysis.
4. Analyze and solve non-linear programming problems by employing techniques for unconstrained and constrained optimization.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Queuing Theory: Introduction, Queuing System, elements of queuing system, distributions of arrivals, inter arrivals, departure service times, and waiting times. Classification of queuing models, Queuing Models: $(M/M/1)$, $(\infty/FIFO)$, $(M/M/1)$, $(N/FIFO)$, Generalized Model: Birth-Death Process, $(M/M/C)$, $(\infty/FIFO)$, $(M/M/C)$, $(N/FIFO)$. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Inventory Control: The inventory decisions, costs associated with inventories, factors affecting Inventory control, Significance of Inventory control, economic order quantity (EOQ), and Deterministic inventory problems without shortage and with shortages, EOQ problems with Price breaks, and multi-item deterministic problems. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Network Analysis- Shortest Path Problem, Minimum Spanning Tree Problem, Maximum Flow Problem, Minimum Cost Flow Problem. Project scheduling by PERT/CPM: Introduction, Basic differences between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM network Components and Precedence Relationships, Critical Path analysis, Probability in PERT analysis. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Non-Linear Programming- One and Multi Variable Unconstrained Optimization, Kuhn-Tucker Conditions for Constrained Optimization, Quadratic Programming, Separable Programming, Convex Programming, Non-Convex Programming. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. G. Hadly: *Non-Linear and Dynamic Programming*, New Delhi: Addision Wesley, Reading Mass, 1967.

Reference Books:

1. H. A. Taha, *Operations Research-An Introduction*, Macmillan Publishing Company Inc., 2006. (For Unit I).
2. A. Ravindran, D.T. Phillips, and J.J. Solberg, *Operations Research: Principles and Practice*, 2nd Edition, John Wiley and Sons, 1987. (For Unit II, III, and IV)
3. F.S. Hiller, and G.J. Liebermann,*Introduction to Operations Research*, Tata McGraw Hill, 2000.
4. K. Swarup, P.K. Gupta, and M. Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi, 2001.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

<table>
<tr><th>MCQ on LMS + Subjective Test</th><th>Syllabus to be covered in the examination</th><th>Time allotted for the examination</th><th>% Weightage (Marks)</th></tr>
<tr><td>Test-I (after 30 days)</td><td>25 %</td><td>1 hour</td><td>10+10</td></tr>
<tr><td>Test-II (after 60 days)</td><td>26 to 50%</td><td>1 hour</td><td>10+10</td></tr>
<tr><td>Theory</td><td>Syllabus to be covered in the examination</td><td>Time allotted for the examination</td><td>% Weightage (Marks)</td></tr>
<tr><td>Major test (after 90 days)</td><td>100 %</td><td>$2\frac{1}{2}$ hour</td><td>60</td></tr>
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<tr><td>Mid Term appraisal</td><td>4 hours</td><td colspan="3">25 %</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75 %</td><td>50 %</td><td>Project Report</td></tr>
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<tr><td colspan="2">Total</td><td colspan="3">100</td></tr>
</table>

Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided for the Test I and Test II**. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II

only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests.**

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER IV

(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE407 **Course Title: Operator Theory**

Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**

Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: Theory of operators on Hilbert spaces has been developed in the course using Banach Algebra Techniques. This course could be useful for persons working in integral equations. Boundary-value problems, ergodic theory and mathematical physics.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Banach Algebra, Multiplicative Functionals Gelfand-Mazur theorem, spectral mapping theorem, Spectral Radius formula.
2. understand Spectrum, point spectrum and approximate points, Spectrum of Unilateral shift.
3. understand Finite rank operators, compact operators and their ideals, Approximation of compact-operators, Fredholm operators and Volterra integral operators.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Banach Algebra and examples, Multiplicative Functionals Gelfand-Mazur theorem, spectral mapping theorem, Spectral Radius formula. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

$\mathbb{C}^*$- algebra, examples and elementary properties of $\mathbb{C}^*$-algebra, commutative Gelfand-Naimark theorem. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Spectral theory of operators on a Hilbert space, Spectral theorem, functional calculus, square root of a positive operator, partial isometrics, Polar decomposition, Spectrum, point spectrum and approximate points, Spectrum of Unilateral shift and invariant and reducing subspaces of unilateral shift and multiplication operators. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

Weak, strong and uniform operator topologies on $B(H)$, Finite rank operators, compact operators and their ideals, Approximation of compact-operators, integral operators, the Calkin Algebras, Fredholm operators, Volterra integral operators, Elementary properties of composition operators on L_p-spaces. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. R. G. Douglas,*Banach Algebra techniques in operator theory*, A.P. 1972 (for Unit-I,III and IV).
2. S. K. Berbarian,*Lectures in Functional analysis and operator theory*, Springer-Verlag, 1973 (for Unit-II).

Reference Books:

1. J. B. Conway, *A course in functional analysis*, Springer-Verlag, 1985.
2. N. Dunford and J. Schwartz, *Linear operators*, Wiley(1958, 1963 Vol.I, II and 1971 I, Vol.III).
3. P. R. Halmos, *A Hilbert space problem Book*, Wps, 1978.
4. P. R. Halmos and V. S. Sunder,*Bounded integral operators on L_2- spaces*, Springer-Verlag, 1978.
5. H. P. Radjavi, *Invariant subspaces*, Springer-Verlag 1973.
6. R. Schatten, *Norm ideals of completely continuous operators*, Springer-Verlag, 1960.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

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<tr><td>25 %</td><td>Viva-voce</td></tr>
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Test I and Test II

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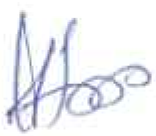

for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020)
University of Jammu.

SEMESTER IV
(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MATE408 **Course Title: Advanced Numerical Techniques**
Credits: 05 (Theory: 04 + Practical/Tutorial: 01) **Level- 500**
Maximum Marks: 125 (Theory: 100 + Practical/Tutorial: 25)

Objectives: The objectives of this course are to make students familiar with the theory of numerical analysis for solving Some numerical methods such as Taylor method, Picard method, Jacobi method, Euler method, Runge-Kutta method, Galerkin methods etc. It contains numerical differentiation and integration, numerical solutions of ordinary and partial differential equations and finite element method. It plays an important role for solving various engineering sciences problems.Therefore, it has tremendous applications in diverse fields in engineering sciences.

Course Learning Outcomes: After studying this course the student will be able to

1. understand numerical differentiation and integration .
2. find the solution of ordinary differential by using Picard method, Runge-Kutta Methods, Predictor methods, the cubic spline method, boundary value problems.
3. understand finite element method and its application to one and two dimensional problems.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration. The tutorial consists of 15 tutorial sessions, each of two hours duration.

Unit-I

Numerical Differentiation and Integration
Introduction, Numerical Differentiation, Numerical Integration, Euler-Maclaurin Formula, Adaptive Quadrature Methods, Gaussian Integration, Singular Integrals, Fourier Integrals, Numerical Double Integration. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-II

Numerical Solution of Ordinary Differential Equations
Introduction, Solution by Taylor's Picard's Method, Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, the Cubic Spline Method, Simultaneous and Higher Order Equations, Boundary Value Problems: Finite-Difference Method, The Shooting Method. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-III

Numerical Solution of Partial Differential Equations
Introduction, Finite-Difference Approximations, Laplace's Equation: Jacobi's Method, Gauss-Seidel Method, SOR Method, ADI Method, Parabolic Equations, Iterative Methods, Hyperbolic Equations. Examples and exercises based on these concepts will be covered in the tutorials.

Unit-IV

The Finite Element Method Functionals-Base Function Methods of Approximation, The Rayleigh-Ritz Method, The Galerkin Method, Application to two dimensional problems, Finite element Method for one and two dimensional problems. Examples and exercises based on these concepts will be covered in the tutorials.

Text Books:

1. S.S. Sastry, *Introduction Methods of Numerical Analysis*, Prentice Hall of India 1998.

Reference Books:

1. Niyogi Pradip, *Numerical Analysis and Algorithms*, Tata McGraw-Hill, New Delhi 1998.
2. E. Balagurusamy, *Numerical Methods*", Tata McGraw-Hill 2017
3. S. C. Chapra and R. P. Canale, *Numerical Methods for Engineers*, Tata McGraw-Hill Education, 2 Penn Plaza, New York, NY 2015.

Scheme of Examination: The student shall be continuously evaluated during the conduct of each course on the basis of his/her performance as follows:

MCQ on LMS + Subjective Test	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Test-I (after 30 days)	25 %	1 hour	10+10
Test-II (after 60 days)	26 to 50%	1 hour	10+10
Theory	**Syllabus to be covered in the examination**	**Time allotted for the examination**	**% Weightage (Marks)**
Major test (after 90 days)	100 %	$2\frac{1}{2}$ hour	60
Total			100

<table>
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Test I and Test II

The subjective Test of Test I and Test II would consist of three short answer type question (05 marks each). Students are required to answer two questions. **No preparatory holidays shall be provided**

for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have one compulsory question comprising of 10 parts (minimum 02 from each unit) of 03 marks each. Section-B will have 04 questions of 15 marks each to be set from the last two units (02 from each unit) Students are required to attempt 01 question from each unit of section B. **In major test there should not be a gap of more than two days in between two tests**.

Syllabi and Course of Study for Two Years Postgraduate Programme in Mathematics (NEP 2020) University of Jammu.

SEMESTER IV

(Examination to be held in May 2027, 2028, 2029)

Course Code: P2MARC409 **Course Title: Research Thesis/Project/Patent**

Credits: 16

Maximum Marks: 400

Research Thesis/Project/Patent work is considered an unique course involving applying knowledge in solving/ analyzing/ exploring a real-life situation/ complex problem/ data analysis. Research Thesis/Project/Patent work has the intention to provide research competencies at the postgraduate level. It enables the acquisition of special/ advanced knowledge through support Research Thesis/Project/Patent work. This course is applicable to students in 4th semester of postgraduate research program. The following mechanism shall be adopted for completion of the Research Thesis/Project/Patent .

1. Research Thesis/Project/Patent work shall be started in the beginning of the 3rd semester and Supervisor/ mentors shall be allotted through DAC in the first week of the 3rd semester.
2. Research Thesis/Project/Patent carries 16 credits carrying 400 marks.
3. The topics of the Research Thesis/Project/Patent shall be allotted by the nominated Supervisor/ mentor and approved by DAC.
4. The evaluation of the Research Thesis/Project/Patent and viva-voce shall be carried out by DAC of the department with following weightage of marks:
   (i) Research Thesis/Project/Patent -280 marks.
   (ii) Viva-voce/ Presentation-120 marks.

Annexure – X

<u>SWAYAM: MOOCs(Study Web of Active Learning by Young and Aspiring Minds)</u>

To widen the access to higher education and to promote use of ICT in Teaching Learning, Massive Online Open Courses (MOOCs) have emerged as viable model for imparting conventional and online education. Indian version of MOOC has been launched on an indigenous platform known as SWAYAM (Study Web of Active Learning by Young and Aspiring Minds) which has been initiated by Government of India to achieve the three cardinal principles of Education Policy- Access, Equity and Quality. The Academic Council and the University Council of the University of Jammu have approved the adoption of the MOOCs through SWAYAM. From the academic session 2020-21, UGCSWAYAM courses have been made mandatory at both UG and PG Levels. PG students are required to earn a minimum of 4 Credits from SWAYAM courses and UG students are required to earn minimum 2 Credits from SWAYAM. These courses are being offered by the faculty from the prestigious institutions of the country. These will add value to the degrees being obtained by the students and make them more employable. Each Department has a Departmental SWAYAM Coordinator who shall help the students in selection of courses and hand hold them throughout their course. The facilities of the Department like Computers, internet and libraries will be made available to the students for enrolment registration and completion of course on/from the SWAYAM Portal of the UGC. Information to all concerned will be available on the Portal https://ugcmoocs.inflibnet.ac.in&https://swayam.gov.in

STANDING INSTRUCTIONS FOR SWAYAM IMPLEMENTATION
(The following Information / Instructions must be followed strictly by all concerned)

1. MOOCs through SWAYAM platform is mandatory for all students enrolled for a Bachelor's or Master's Degree programme in the University of Jammu or its affiliated Colleges w.e.f. Academic Session 2020-21 onwards.
2. A minimum of one course of 4-Credit has to be earned, subject to the maximum of 10% of total credits for the completion of degree by all regular students of PG/UG stream from the SWAYAM platform depending upon the availability of courses as notified by UGC generally on predefined dates, 1st June or 1st November, every year.
3. Courses must be identified by all Departments duly approved by Departmental Affairs Committee (DAC) or by Swayam Academic Cell (SAC) as the case may be, latest by the 25th of June for June notified courses and similarly by 25th of November for November notified courses by UGC, and must be sent to the DEAN ACADEMIC AFFAIRSwithin a weeks' time from date of commencement of 3rd Semester.
4. Departmental Affairs Committee (DAC) / Swayam Academic Cell (SAC) must be empowered for the selection of MOOCs by Convenor, BOS /Dean of the concerned faculty.
5. Department Swayam Coordinator (DSC) or College Swayam Coordinator (CSC) must brief the students of 1st semester within the first week of commencement of the first semester, preferably during induction programme, about SWAYAM and its related issues,for every newly admitted batch, as a regular feature.
6. Preferably for earning the required 4 credits, a single course must be selected from SWAYAM Platform. However, final combination of earning 4 credits shall be left to the DSC and the students, which must be completed on or before 3rd/5th/9th Semesters as the case may be.
7. The DCS of the concerned Department must brief the students during the Induction Program, all the issues associated with SWAYAM MOOCs (As given in the booklet).
8. The student can selectcourses either from technical (NPTEL) and non-technical (UGC) MOOCs from SWAYAM Portal (www.swayam.gov.in)
9. In case the credits are not specified for a given MOOC, the DSC or CSC must ensure a minimum of 12 weeks (72 hrs) course to qualify for the 04-credit course.
10. MOOCs will be treated as Open Course inlieu of Open course of 3rd semester course offered by University.
11. The student must complete the SWAYAM course successfully before the commencement of the final semester of a stream or discipline.
12. Students can select the MOOC course of their choice from a pool of courses selected by the Departments or Colleges, of any stream or any other course of their choice with prior information to Departmental SWAYAM Coordinator(DSC) or College SWAYAM Coordinator (CSC) and it shall be the duty of the Departmental SWAYAM Coordinator(DSC) or College SWAYAM Coordinator (CSC) to forward these selected new courses through the Convener, BOS, under information to Dean Academic Affairs.
13. Departments/ Colleges must ensure that all logistic support whatever is required by the student, must be supplemented/extended.
14. Student ideally should not select self-paced MOOCs, and the courses selected must be different from one offered in the course curriculum of semesters in order to avoid duplication.
15. The student must fill an undertaking form, as given in the brochure,and submit the same after duly filled form to their respective Departments/ Colleges for future reviews and record purposes.
16. Students must follow the schedule of the host institution in completing the course successfully and for all doubts must contact the Course Coordinator or the Departmental/ College SWAYAM Coordinator (DSC/CSC).
17. Any issue or problem related to SWAYAMmust be brought to the notice of the University SWAYAM Coordinator, immediately, through the DSC and Head, without fail, so that it can be addressed in time.

18. The student must keep a note of and also supply the information such as registration date/ enrolment id, email-id, phone, name, semester etc. to their DSC/CSC.
19. SWAYAM Examination fees (if any), or any other fee prescribed,shall be borne by the students only.
20. The Examination fee once paid shall not be refundable.
21. Since there is no re-examination systemtherefore, candidate has to re-opt in the next cycle/ session if he/she is unable to complete the SWAYAM MOOCs successfully for whatsoever reason.
22. The concerned may note that all University/ Departmental Examinations must be rescheduled or readjusted if needed, to avoid any clash with SWAYAM Examination schedule, to avoid hardships to the students.
23. The student must submit a valid course completion certificate as a proof (Photocopy/ print copy) to their respective DSC/CSC before the beginning of the final semester, failing which their degree will be withheld.
24. A bi-annual data collection of information regarding SWAYAM enrolment , as per prescribed format available on University Websiteon pre-proposed fixed dates, preferably 5th October and 5th March, every year for the sessions of June and November, respectively must be done. This responsibility of sending soft copy information as per prescribed format shall lie with the Department/College SWAYAM Coordinator to the Directorate of Internal Quality Assurance (DIQA) to the **email-id: iqac_ju@yahoo.com with copy to UGCSwayam coordinator of the University**
25. All records of MOOCs related information must be preserved for two years from date of passing out by the student from the department or college as the case be.

SWAYAM/ MOOCs DECLARATION FORM FOR THE STUDENT

TO WHOM IT MAY CONCERN

I, ..., Ward of ...., Roll No:........., Mobile No: ...., Email:..........................: Department / College .... Session.................. Semester.........., have read the SWAYAM instructions/information given in the Jammu University Admission Brochure. Accordingly, I will choose at least one 4-credit MOOCs (Minimum) from SWAYAM platform as per University policy, and complete it successfully on or before the completion of my 3rd/5th/9th semesters (as the case may be) and provide the valid Course Completion Certificate/ Result, to the respective DSC of the department concerned for further needful, failing which my result may be withheld. I understand that any Fee that is applicable during completion of the said course will be borne by me.

Signature of Candidate

Date:
Place: