MAHAKAUSHAL UNIVERSITY, JABALPUR M.P.

Approved by Higher Education and the Governor of M.P.

Faculty of Science

Scheme & Syllabus

For

Subject- Mathematics

M.Sc. Programme

(1 Year PG Diploma/1 Year PG/2Year PG Programme

I to IV Semester

2025-26

Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – I)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	Advanced Abstract Algebra - I (Theory)		
3	Course Type	MMAT0101-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understand the basic concepts of group operations and their applications. 2. Apply the Sylow's theorem to characterize certain finite groups. 3. Know the fundamental concepts in ring theory such as polynomial rings, Euclidean domain and unique factorization domain. 4. Learn the fundamental properties of extension of a field. 5. Analyze and the characterize algebraic and transcendental extensions.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Advanced Abstract Algebra: Dr. Harish-Chandra, Dr. V. V. Narlikar, Dr. S. S. Abhyankar	02
II	Class equation of a finite group, Centre for Group of prime power order, Cauchy's and Sylow's theorems for finite groups, Isomorphism theorems, Maximal normal groups, Simple groups. ***Suggested Activities:*** *By analyzing conjugacy classes, determine the center of the group and identify normal subgroups. Determining the structure of groups based on Sylow p-subgroups.*	18
III	Normal and Subnormal Series, Composition series of a group, Jordan-Holder theorem, Commutator subgroup of a group, Solvable groups, Nilpotent groups. ***Suggested Activities:*** *Used in the classification of finite simple groups, providing foundation for understanding group structures. Applying the commutator subgroup to analyzing the fundamental group of topological spaces.*	15

IV	Euclidean ring, Polynomial ring, Polynomials over a Ring, Division algorithm, Polynomial over the rational field. ***Suggested Activities:*** *Discuss how Euclidean ring and Division algorithm be used in cryptography.*	15
V	Euclidean domain, Principal ideal domain, Unique factorization domain, Quotient field. ***Suggested Activities:*** *Discuss how Euclidean domain and Unique factorization domain can be used in cryptography.*	10
VI	Extension of a fields, Roots of polynomials, Algebraic and transcendental extensions, Primitive elements, Algebraically closed field. *Suggested Activities: Discuss the applications of field extension and primitive elements in real world problems.*	15

Keywords/Tags:
Cauchy's and Sylow's theorems, Jordan-Holder theorem, Solvable groups, Nilpotent groups, Euclidean rings, Polynomial rings, Euclidean domain, Principal ideal domain, Unique factorization domain, Quotient field, Extension Field.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul: Basic Abstract Algebra, 2nd edition, Cambridge University Press, 2003.
2. I. N. Herstein: Topics in Algebra, Wiley Eastern Ltd. New Delhi. 1977.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. I. S. Luther and I. B. S. Passi: Algebra. Vol. I and II, Narosa Publishing House, 1997.
2. Shanti Narayan: A text Book of Modern Abstract Algebra, S. Chand and Company. New Delhi, 1967.
3. Surjeet Singh and Qazi Zameeruddin: Modern Algebra, Vikas Publishing House Pvt Ltd; Delhi, Eighth edition, 2006.

Suggested Digital Platforms Web links:

https://www.eshiksha.mp.gov.in/mpdhe

https://epgp.inflibnet.ac.in

Suggested Equivalent online courses:

https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/335

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – I)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	Topology – I (Theory)		
3	Course Type	MMAT0102-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Determine interior, closure, boundary and limit points of metric space. 2. Determine interior, closure, boundary, limit points, basis and sub-basis of topological spaces. 3. 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. 4. Identify the continuous maps between two spaces and maps from a space into product space. 5. Determine common topological properties of given two spaces.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Topology: Dr. M. S. Narasimhan, Dr. V. S. Varadarajan	02
II	**Metric Space:** Definition, examples and types of Metric spaces. Neighborhoods, Limit points, Interior points and Boundary points. Open and closed sets. Closure and interior of a set. Subspace of a Metric space. Sequences in a Metric space: Convergent sequence, Cauchy sequences. Completeness of a Metric space. Cantor's intersection theorem. Contraction principle. Dense subsets, Baire Category theorem. Continuous functions.	18
	Suggested Activities: Discuss about the applications of Closure of a set, Interior points, Boundary points and Baire Category theorem.	

III	**Topological Spaces:** Definition and examples of topological spaces. Neighbourhood of a point, limit point and derived set. Closed set and closure of a set. Dense set and nowhere dense set. Interior, exterior and boundary points of a set.	15
	Suggested Activities: Discuss about the applications of Closure of a set, Interior, exterior and boundary points of a set in topological space.	
IV	**Relative Topology and Bases:** Topological subspace and relative topology. Basis and subbasis. First and second countable spaces and separable spaces.	10
	Suggested Activities: Discuss how Topological Subspaces be used in Computer graphics, GIS, robotics.	
V	**Continuity and Homeomorphism:** Continuity in topological spaces, Sequential Continuity at a point, Open and closed functions, Homeomorphism of topological spaces, Topological property.	15
	Suggested Activities: (i) Discuss application of Homeomorphism in Robotics. (ii) Discuss how Sequential Continuity be used in Machine Learning.	
VI	**Connectedness:** Separated sets, Connected and Disconnected Sets, Continuity and Connectedness, Component of a space. Totally disconnected spaces, Locally connected spaces.	15
	Suggested Activities: Discuss the applications of Separated Sets, Connected and Disconnected Sets to solve the real-world problems.	

Keywords/Tags:
Metric Space, Topological Spaces, Continuity and Homeomorphism in topological spaces, Separable spaces in topological space.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Education, 2017.
2. J. R. Munkres: Topology, Pearson; 2nd edition, 2015.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. K. D. Joshi: Introduction to General Topology, New Age International Private Limited, 2017.
2. T. B. Singh, Elements of Topology, CRC Press, Taylor & Francis, 2013.
3. K. Chandrasekhara Rao: Topology, Narosa Publishing House, 2009.

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Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
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Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – I)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	Real Analysis (Theory)		
3	Course Type	MMAT0103-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Learn the properties of Riemann and Riemann-Stieltjes integrable functions and applications of the fundamental theorems of integration. 2. Understand the concepts of convergence and term by term integration and differentiation of a power series. 3. Understanding and evaluating uniform convergence of series of real valued functions. 4. Analyzing the relation between uniform convergence and continuity, uniform continuity and differentiation and integration of sequences of real valued functions.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Real Analysis: Dr. K. Chandrasekharan, Dr. D. S. Kothari	02
II	**Real Number System:** Introduction, Denseness property, Neighbourhood, Limit Points of a set, Open and Closed Set, Interior and Closure of a Set, Bolzano-Weierstrass Theorem. *Suggested Activities: Discuss Limit Points of a set, Open and Closed Set, Interior and Closure of a Set.*	5
III	**Riemann Integral, Integration and Differentiation:** Riemann Integral: Properties of Riemann sums, Riemann integrability, Properties of Riemann integrable functions, Riemann integration and continuity, Integral as a limit of sums. Integration and Differentiation:	

	Fundamental theorem of calculus, Mean value theorems of integral calculus, Integration by parts, Change of variables. *Suggested Activities: Understanding the properties of Riemann integrable functions and their applications.*	
IV	**Riemann-Stieltjes Integral:** Definition, existence and properties of Riemann-Stieltjes integral, Relation Between Riemann and Riemann-Stieltjes integral, Mean value theorem, Integration and differentiation, Fundamental theorem of calculus for Riemann-Stieltjes integral, Integration of vector valued functions, Rectifiable curves. *Suggested Activities: Gives the applications of Riemann-Stieltjes Integral in various fields.*	15
V	**Improper Integral and Fourier Series:** Improper integrals and their convergence: Comparison tests and μ-test, Abel's and Dirichlet's tests. Absolute and Conditional convergence of improper integrals, Frullani's integral as a function of a parameter, Differntiability & integrability of an integral of a function of a parameter, Fourier series for half and full intervals. *Suggested Activities: Discuss the application of Fourier Series in Signal Processing and Communications.*	18
VI	**Uniform Convergence and Power Series:** Pointwise and uniform convergence of sequences of functions: Cauchy's general principle of uniform convergence, Weierstrass M_n-Test, Uniform convergence of series of functions: Weierstrass M-test, Uniform convergence, continuity, differentiability and Riemann integrability. Algebra of power series: Uniform convergence of power Series, Uniqueness of power series, Abel's theorem, Properties of power series, Tauber's theorem. *Suggested Activities: Analyzing the relation between uniform convergence and continuity.*	20

Keywords/Tags:
Real Numbers, Riemann Integral, Riemann-Stieltjes Integral, Improper Integral, Fourier Series, Uniform Convergence, Power Series.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. Walter Rudin: Principles of Mathematical Analysis, McGraw Hill Education, Third edition, 2017.
2. S. C. Malik and Savita Arora: Mathematical analysis, New Age Publication. Delhi, 2017.
3. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Education, 2017.
4. Goldberg R R: Methods of Real Analysis, Oxford & IBH Publishing, 2020.
5. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. Santi Narayan and M. D. Raisighania: Elements of Real Analysis, S Chand, 2003.
2. J. R. Munkres: Topology, Pearson; 2nd edition, 2015.
3. D. Somasundaram and B. Choudhary: A First Course in Mathematical Analysis, Narosa Publishing House, 1996.

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https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25

Suggested Equivalent online courses:

https://nptel.ac.in/courses/111106142/
https://nptel.ac.in/courses/111106153/
https://nptel.ac.in/courses/111106141/

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – I)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	Complex Analysis (Theory)		
3	Course Type	MMAT0104-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere. 2. Recognize the significance of differentiability and analyticity of complex functions. 3. Use Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals. 4. Apply Liouville's theorem in fundamental theorem of Algebra. 5. Learn Taylor and Laurent series expansions of analytic functions. 6. Classify the nature of singularity, poles and residues and apply Cauchy residue theorem.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Complex Analysis: Dr. C. T. Rajagopal, Dr. S. Minakshisundaram	02
II	**Complex Number and Functions:** Introduction of complex numbers and their geometrical representation: Extended complex plane, Stereographic projection of complex numbers. Continuity and differentiability of complex functions, Analytic functions, Cauchy-Riemann equations, Harmonic functions, Polar form of Cauchy-Riemann equations.	15
	Suggested Activities: *Discuss the applications of Cauchy-Riemann equations and Harmonic functions.*	

III	**Complex Integration:** Definition and examples of complex integration, Absolute value of a complex integral, Cauchy's Theorem, Cauchy's-Goursat theorem, Cauchy's integral formula, Higher order derivatives, Morera's theorem, Cauchy's inequality, Liouville's theorem, Taylor's theorem, Laurent theorem. ***Suggested Activities:*** *Using Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals.*	18
IV	**Poles, Zeros and Singularities:** Introduction of poles, zeros and singularities, Meromorphic function, Argument principle, Rouche's theorem, Fundamental theorem of algebra, Maximum modulus principle, Schwarz lemma. ***Suggested Activities:*** *Discuss the applications of Argument principle and Rouche's theorem.*	15
V	**Calculus of Residues:** Residue, Cauchy's Residue theorem, Evaluation of integrals: $\int_0^{2\pi} f(cos\theta, sin\theta)\, d\theta$, $\int_{-\infty}^{\infty} f(x)\, dx$, $cosmx$ and $sinmx$ as a factor in the integrand, Integration of many valued functions. ***Suggested Activities:*** *Discuss the applications of Calculus of Residues to solve various problems.*	15
VI	**Mobius Transformation and Conformal Mapping:** Mobius Transformation, their properties and classification, Conformal Mapping and their properties. ***Suggested Activities:*** *Real world applications of Mobius Transformation and Conformal Mapping.*	10

Keywords/Tags:
Complex Numbers, Complex Function, Complex Integration, Poles, Zeros, Singularities, Calculus of Residues, Mobius Transformation, Conformal Mapping.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. L. V. Alhfors: Complex Analysis, McGraw Hill Education; Third edition, 2017.
2. T. Pati: Functions of a Complex Variables, Pothishala Pvt. Ltd, 1986.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. Ponnuswamy S: Foundations of Complex Analysis, Alpha Science International Ltd, 2nd edition, 2005.
2. V. Karunakaran: Complex Analysis, Narosa Publication, 2005.
3. Kayalal Pachaiyappa: Complex Analysis, S. Chand and Company Ltd., 2014.

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https://www.eshiksha.mp.gov.in/mpdhe
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Assessment and Evaluation

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Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – II)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	Advanced Abstract Algebra - II (Theory)		
3	Course Type	MMAT0201-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Learn the fundamental properties of finite field extensions and classification of finite fields. 2. Analyzing the characterize perfect fields using separable extensions. 3. Construct examples of automorphism group of a field and Galois extensions. 4. Understand Modules, Identify and construct example of modules and apply homeomorphism theorems on the same. 5. Distinguish between free, simple and semi-simple modules.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Advanced Abstract Algebra: Dr. C. S. Seshadri, Dr. M.S. Raghunathan, Dr. R. Balasubramanian	02
II	Splitting fields, Normal extensions, Finite fields, Classification of finite fields, Separable and inseparable extensions. ***Suggested Activities:*** *Discuss about the applications of Splitting fields and Finite fields in Cryptography.*	14
III	Perfect field, Simple extension, Automorphism of extensions, Fixed field, Artin theorem. ***Suggested Activities:*** *Discuss how Perfect field and Fixed field be used in coding theory.*	14
IV	Galois extension, Fundamental theorem of Galois theory, Fundamental theorem of Algebra, Roots of unity, Cyclic extensions, Polynomials solvable by radicals.	15

	Algebra and cyclic extension are useful in computer science.	
V	Introduction of Modules and their properties. Submodules, Quotient modules, Home orphism and Isomorphism of modules.	15
	Suggested Activities: Discuss how modules be used in coding theory.	
VI	Cyclic modules. Simple modules, Semi-simple modules, Free modules, Schur's lemma.	15
	Suggested Activities: Discuss the applications of Free modules and Schur's lemma.	

Keywords/Tags:
Splitting fields, Perfect field, Normal and Separable Extension, Galois Theory, Cyclic extensions, Modules, Free modules, Schur's lemma.

Part C-Learning Resources

Text Books, Reference Books, Other resources

Suggested Readings:

Text Books:

1. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul: Basic Abstract Algebra, 2nd edition, Cambridge University Press, 2003.
2. N. Herstein: Topics in Algebra, Wiley Eastern Ltd. New Delhi. 1977.
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Reference Books:

1. I. S. Luther and I. B. S. Passi: Algebra. Vol. Land II, Narosa Publishing House, 1997
2. 2. Shanti Narayan: A text Book of Modern Abstract Algebra, S. Chand and Company. New Delhi, 1967.
3. Surjeet Singh and Qazi Zameeruddin: Modern Algebra, Vikas Publishing House Pvt Ltd; Delhi, Eighth edition, 2006.

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Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – II)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	Topology - II (Theory)		
3	Course Type	MMAT0202-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understand separation axioms T0, T1, T2, T3, T4-spaces their characterization and basic properties. 2. Recognize the compactness, sequentially and countably compact sets, Stone-Cech compactification. 3. Using the Tychonoff product topology in terms of standard subbase and its characterizations. 4. Able to prove Tychonoff's theorem, Understand Countability and product spaces.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Topology: Dr. Kapil Paranjape, Dr. Sankaran Viswanath	02
II	Basic properties of compactness, Compactness and Finite Intersection Property, Compactness and Bolzano-Weierstrass Property, Heine Borel Theorem, Local compactness, Lindeloff Spaces and Theorem. ***Suggested Activities:*** *Discuss the applications of Finite Intersection Property and Bolzano-Weierstrass Property.*	15
III	T_0-Spaces or Kolmogrov Spaces, T_1-Spaces or Quasi-separated Spaces, T_2-Spaces or Hausdorff Spaces, T_3-Spaces or Regular Spaces, T_4-Spaces or Normal Spaces. *Suggested Activities: Discuss how T_2-Spaces and T_3-Spaces be used in Machine Learning and Robotics.*	18
IV	Completely Normal Spaces, Completely Regular Spaces, Tychonoff Spaces, One-Point Compactification, Stone-Cech compactification.	10

	Stone-Cech compactification to solve the problems related to Machine Learning, and Robotics.	
V	Tychon off product topology in terms of standard subbase and its characterizations, Projection Function, Characterization of Tychon off product. Suggested Activities: Discuss the applications of Characterization of Tychon off product.	15
	Suggested Activities: Discuss the applications of Characterization of Tychon off product.	
VI	Separation axioms and product spaces, Connectedness and product spaces, Compactness and product spaces, Tychon off's theorem, Countability and product spaces.	15
	Suggested Activities: Discuss the applications of Compactness and product spaces, Tychon off's theorem in Machine Learning and Robotics.	

Keywords/Tags:
Compactness in topological spaces, Local compactness, Separable spaces in topological space, Connectedness and product spaces, Countability and product spaces.

Part C-Learning Resources

Text Books, Reference Books, Other resources

Suggested Readings:

Text Books:

1. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Education, 2017.
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Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – II)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	Lebesgue Measure and Integration (Theory)		
3	Course Type	MMAT0203-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understand and identify Lebesgue outer measure. 2. Using of Integration of non-negative functions and apply Riemann and Lebesgue integrals. 3. Understand the four derivatives, Lebesgue differentiation theorem. 4. Understand the L^p-spaces, Hölder and Minkowski inequalities. 5. Recognize the convergence in measure, uniform convergence and almost uniform convergence.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Lebesgue Measure and Integration: Dr. M. G. Nadkarni, Dr. R. Balakrishnan, Dr. K. R. Parthasarathy	02
II	Lebesgue outer measure, Measurable sets, Regularity of a measure, Measurable function, Borel and Lebesgue measurability of sets, Non-measurable sets. *Suggested Activities: Discuss on applications of Lebesgue Outer Measure, and Measurable Sets in modern technology.*	14
III	Lebesgue Measurable Function and its Properties, Step Function, Operations on Measurable Functions, Characteristic Function, Simple Function, Borel Measurable Function, Littlewood's three principles. *Suggested Activities: Used in defining loss functions over continuous data distributions. Application of Characteristic Function in Machine Learning.*	14
IV	Lebesgue Integral of a Bounded Function Over a Set of Finite Measure, Properties of Lebesque Integral for Bounded Measurable Functions. Integral of Non-Negative Measurable Functions.	15

	Suggested Activities: *Discuss on applications of Properties of the Lebesgue Integral in Economics, Signal Processing.*	
V	The four derivatives, Functions of bounded variations, Lebesgue differentiation theorem, Differentiation and integration, Integral of Derivative.	15
	Suggested Activities: *Discuss how Lebesgue Differentiation Theorem be used in Machine Learning, Finance and Thermodynamics.*	
VI	The L^p-spaces, Convex functions, Jensen's inequality, Hölder and Minkowski inequalities for L^p-spaces, Completeness of L^p, Convergence in measure, Almost uniform convergence.	15
	Suggested Activities: Analysing how L^p-spaces and Almost Uniform Convergence can be used in Machine Learning and Signal Processing.	

Keywords/Tags:
Lebesgue outer measure, Littlewood's three principles, Lebesgue Integral, The four derivatives, Hölder and Minkowski inequalities for L^p-spaces.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. G. de Barra, Measure Theory and Integration, Wiley-Eastern Ltd.,1981.
2. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. Walter Rudin, Principles of Mathematical Analysis (3rd Edition), McGraw-Hill, Kogakusha, 1976, International Student Edition.
2. H. L. Royden, Real Analysis, Macmillan Publishing Co. Inc., 4th Edition, New York, 1993.
3. I. K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, 1997.
4. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New-Age International (P) Ltd., New Delhi, 1986.

Suggested Digital Platforms Web links:
https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25

Suggested Equivalent online courses:
https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/335

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A Introduction

Program: 2-Year Post-Graduate Programme	Class: Post-Graduate I-Year (Semester – II)	Year: 2025	Session: 2025-2026

Subject: Mathematics

1	Course Code	
2	Course Title	Differential Geometry (Theory)
3	Course Type	MMCB0204-T
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understand parametric representation of a curve and a surface, Osculating Plane. 2. Understand curvature and principal normal, Circle of curvature, Able to prove Frenet-Serret formulae. 3. Understand Locus of centre of curvature, Osculating sphere, Involutes and Evolutes of a curve. 4. Derive tangent plane to a surface, Understand Ruled surfaces. 5. Introduce with curvilinear co-ordinates, Understand Fundamental Magnitude of first order.
6	Credit Value	5 Credits
7	Total Marks	Max. Marks: 40 + 60 | Min. Passing Marks: 40

Part B - Content of the Course

Total No. of Lectures (in hours per week): 5 hours per week
Total Lectures: 75 hours

Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Differential Geometry: Dr. K. Varadarajan, Dr. Rajendra Bhatia, Dr. M. S. Narasimhan	02
II	Curve in Space: Tangent to Curve, Curvature, Torsion, Frenet-Seret Formulae, Contact of a Curve and a Surface. ***Suggested Activities:*** *Discuss how Tangent to a Curve and Torsion be used in Robotics.*	15
III	Osculating Plane (Plane of Curvature), Helix, Osculating Circle (Circular Curvature), Locus of Centre of Circular Curvature, Osculating Sphere (Spherical Curvature), Locus of Centre of Spherical Curvature. ***Suggested Activities:*** *Discuss on applications of Osculating Plane in Aerospace and Osculating Sphere in Aerodynamics.*	18
IV	Involute and Evolute Curve, Curvature and Torsion of Involute Curve, Curvature and Torsion of Evolute Curve. ***Suggested Activities:*** *Discuss on applications of Curvature & Torsion of Involute in Biomechanics, Curvature & Torsion of Evolute in Neuroscience.*	1(

V	Surface: First and Second Fundamental Form, Normal Curvature, Principal Curvature, Line of Curvature, Derivative of Unit Normal, Rodrigues Formula.	15
	Suggested Activities: *Discuss how Normal Curvature be used in Biomechanics and Principal Curvatures can be used in Medical Imaging.*	
VI	Jochi-Misthal Theorem, Angle Between Two Directions, Condition for Orthogonal Families of Curves, Euler's Theorem, Umbilics Points and Surface, Meuniers Theorem.	15
	Suggested Activities: *Discuss on applications of Umbilic Points and Surfaces in Medical Imaging and Angle Between Directions in Robotics.*	

Keywords/Tags:
Curve in Space, Frenet-Seret Formulae, Osculating Plane, Involute and Evolute Curve, Surface, Normal Curvature, Principal Curvature, Umbilics Points and Surface.

Part C - Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. R. S. Mishra, A course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad,1965.
2. B. B.Sinha, Differential Geometry-An Introduction, Shyam Prakashan Mandir, Allahabad, 1978.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. C. E.Weatherburn, An Introduction to Tensor Calculus and Riemannian Geometry, Cambridge University Press, London, 1942 and Radha Publishing House Calcutta, Indian Edition, 1995.
2. T. J.Willmore, Differential Geometry, Oxford University Press, London, 1959 and Indian XI Edition, New Delhi, 1993.
3. L. P. Eisenhart, Differential Geometry with the use of Tensors, Princeton University Press, New Jersey, 1949.

Suggested Digital Platforms Web links:
https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/Home/ViewSubject

Suggested Equivalent online courses:
https://nptel.ac.in/courses/111104095
https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/364

Chairman

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme		**Class:** Post-Graduate I-Year (Semester – II)	**Year:** 2025	**Session:** 2025-2026
Subject: Mathematics				
1	Course Code			
2	Course Title	**Foundational Skills for Career Success** (Theory)		
3	Course Type	VAC (CHM/EESC)		
4	Pre-requisite (if any)	To study this course, a student must have had any subject at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Use appropriate tone, pitch, and language based on audience and purpose. 2. Interpret body language, facial expressions, and gestures accurately. 3. Analyze sentence components to improve grammar and clarity. 4. Conduct a personal SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. 5. Develop strategies to stay motivated and maintain a positive mindset. 6. Understand the functions and features of common presentation software (e.g., PowerPoint, Google Slides). 7. Insert and format text using headings, bullet points, and styles. 8. Integrate animations, transitions, and multimedia (audio, video) into presentations.		
6	Credit Value	2 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 2 hours per week **Total Lectures:** 30 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Gurukul – Discipline & Time Management, *Natyashastra* – Critical Thinking, Panini's Ashtadhyayi – Communication.	02
II	**Communication Skills:** Verbal Communication, Non-Verbal Communication, active Listening, Writing Skills: Parts of Speech, Sentences. **Self-management Skills:** Strength and Weakness Analysis, Motivation and Positive Attitude, Result Orientation, Self-awareness.	14
	Suggested Activities: *Practice mock interviews, Peer Editing, SWOT Activity, Case Study Analysis, "Who Am I?" Exercise.*	

III	**Information and Communication Technology Skills:** Presentation Software, Opening, Closing, Saving and Printing a Presentation, Working with Slides and Text in a Presentation, Advanced Features used in Presentation.	14
	Suggested Activities: Presentation Basics Relay, Slide Design Challenge, Create a Tutorial Presentation.	

Keywords/Tags:
Communication Skills, Self-management Skills, ICT Skills.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

1. Employability Skills, Textbook for Class IX, NCERT Publication, 2018.
2. Employability Skills, Textbook for Class XII, NCERT Publication, 2020.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Suggested Digital Platforms Web links:
https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001610/P001800/M025909/ET/1513941412MODULE9SkillsforEmployment,LifeSkillsandEntrepreneurshipFinal20.9.2017-Edited.pdf
https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001610/P001800/M025902/ET/1513941219MODULE2PersonalityDevelopment-Edited.pdf

Suggested Equivalent online courses:
https://nptel.ac.in/courses/109104115
https://nptel.ac.in/courses/109104107

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-I)		Class: Post-Graduate II-Year (Semester – III)	Year: 2026	Session: 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Functional Analysis - I (Theory)		
3	Course Type	MMAT0301-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understanding the Normed linear spaces, Banach spaces, Linear operator, Linear functional. 2. Analyzing the Properties of Normed linear spaces, Bounded linear operators and Bounded linear functional. 3. Evaluating the examples of Banach spaces, Dual space.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week Total Lectures: 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Functional Analysis: Dr. M. S. Narasimhan, Dr. S. R. S. Varadhan	02
II	Normed linear spaces, Properties of Normed linear spaces. Holder's, Minkowski's and Cauchy's inequalities. Banach spaces and examples. ***Suggested Activities:*** *Discuss the applications of Normed Linear Spaces, Hölder's Inequality and Minkowski's Inequality in Machine Learning and data science.*	15
III	Finite dimensional normed linear spaces and subspaces. Quotient space of normed linear spaces and its completeness. *Suggested Activities: Discuss how Finite dimensional normed linear spaces and subspaces are used in Machine Learning and Signal Processing.*	14
IV	Bounded and Continuous linear operators, Equivalent norms, Riesz lemma and compactness. ***Suggested Activities:*** *Discuss the applications of Bounded & Continuous Linear Operators in signal processing.*	15
V	Linear functional, Dual spaces and Reflexive spaces. Hahn-Banach theorem for real linear spaces, Hahn-Banach theorem for complex linear space and normed linear spaces.	14

	Suggested Activities: Discuss the application of Linear functional in Machine Learning and Hahn-Banach theorem in Game Theory.	
VI	Baire's Category Theorem. Uniform Boundedness theorem. Open mapping and Closed graph theorems.	15
	Suggested Activities: Discuss on Baire's Category Theorem and Closed graph theorem to solve real world problems.	

Keywords/Tags:
Normed linear space, Banach space, Bounded and Continuous linear operators, Linear functional, Baire's Category Theorem.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. E. Kreyzig, Introductory Functional Analysis with applications, John Wiley and Sons, New York, 1978.
2. G. F. Simmons, Introduction to Topology and Modern Analysis Mc Graw Hill, New York, 1983.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. B. Choudhary and Sudarshan Nanda, Functional Analysis with applications, Wiley Eastern Ltd., 2018.
2. P. K. Jain, O. P. Ahuja and Khalil Ahmad, Functional Analysis, New Age International (P) Limited, 1997.
3. K. K. Jha, Functional Analysis and its Applications, Students' Friend, 1986.
4. B. V. Limaye, Functional Analysis, Wiley Eastern Ltd.

Suggested Digital Platforms Web links:
https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25

Suggested Equivalent online courses:
https://nptel.ac.in/courses/111/105/111105037/
https://nptel.ac.in/courses/111/106/111106147/

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-I)		**Class:** Post-Graduate II-Year (Semester – III)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Advanced Special Functions - I (Theory)		
3	Course Type	MMAT0302-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understand Gamma, Beta functions and difference equation. 2. Compute $\Gamma(z)\Gamma(1-z)$, Factorial function and Gauss multiplication theorem. 3. Recognize Hypergeometric and contiguous function relations. 4. Use Hypergeometrical differential equation, elementary series manipulations. 5. Applications of Bessel function in various field such as Industry etc.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Advanced Special Functions: Srinivasa Ramanujan, Dr. Harish-Chandra	02
II	Gamma and Beta Functions: The Euler or Mascheroni Constant γ, Introduction to Gamma Function, Series for $\Gamma'(z) / \Gamma(z)$, Difference equation $\Gamma(z+1) = z\Gamma(z)$. *Suggested Activities: Discuss the applications of Gamma and Beta Functions.*	15
III	Introduction to Beta function, Value of $\Gamma(z)\Gamma(1-z)$, Factorial function, Legendre's duplication formula, Gauss multiplication theorem. *Suggested Activities: Discuss the various applications of Legendre's duplication formula and Gauss multiplication theorem.*	14
IV	Hypergeometric functions: Function ${}_2F_1(a, b; c; z)$, Simple integral form of ${}_2F_1(a, b; c; z)$, Evaluation of ${}_2F_1(a, b; c; 1)$, Contiguous function relations.	15

	Suggested Activities: *Discuss the applications of Hypergeometric Function ${}_2F_1(a, b; c; z)$ to solve real world problems.*	
V	Hypergeometrical differential equation and its solutions, Elementary series manipulations, Simple transformation, Relations between functions of z and (1 – z). ***Suggested Activities:*** *Discuss how Elementary Series Manipulations and Relations between functions of z and (1 – z) are used in Signal processing, machine learning and cryptography.*	14
VI	Bessel Function: Definition of $J_n(z)$, Bessel's differential equation, Generating function, Bessel's integral with index half and an odd integer. ***Suggested Activities:*** *Discuss the applications of Bessel function in Signal Processing, Control Systems and Medical Imaging.*	15

Keywords/Tags:
Gamma and Beta Functions, Legendre's duplication formula, Hypergeometric Functions, Simple transformation, Bessel Functions, Bessel's integral with index half and an odd integer.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. Rainville, E. D.: Special Functions, The Macmillan Co., New York, 1971.
2. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. Lebdev, N. N.: Special Functions and Their Applications, Prentice Hall, Englewood Cliffs, New Jersey, USA 1995.
2. Saran, N., Sharma, S. D. and Trivedi, T. N.: Special Functions with Application, Pragati Prakashan, 2019.

Suggested Digital Platforms Web links:

https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/Home/ViewSubject

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-2)		Class: Post-Graduate II-Year (Semester – III)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Advanced Discrete Mathematics (Theory)		
3	Course Type	MMAT0303-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Differentiate regular, context-free and recursively enumerable languages. 2. Explain the basic concepts of finite automata and regular expressions. 3. Understand Non-deterministic fine automata, Finite automata, Moore and Mealy Machines. 4. Design and construct a Turing machine for a computer language. 5. Recognize core concepts relating to the theory of computation and computational models.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Advanced Discrete Mathematics: Pingala - Chandahśāstra, Bhaskara II, Dr. C. R. Rao, Dr. Narendra Karmarkar	02
II	**Finite Automata and Regular Languages:** Alphabets, strings and languages; Regular expressions, regular grammar and regular languages, Finite automata, Regular languages and their relationship with finite automata, Pumping lemma for regular languages, Closure properties of regular languages. ***Suggested Activities:*** *Discuss the applications of Finite Automata and Regular Languages in Artificial Intelligence & Robotics and Network Security.*	13
III	**Finite State Machine:** Finite state machines, their transition table and diagrams; Equivalence of finite state machines, Reduced machines, Finite state machines and homeomorphism, Finite State Machines as language recognizer.	15

	Suggested Activities: Discuss the applications of Finite State Machine in Robotics & Automation and Telecommunications.	
IV	**Deterministic and non-deterministic finite automata:** Deterministic finite automata, Non-deterministic finite automata, Difference between deterministic and non-deterministic finite automata; Conversion from non-deterministic to deterministic finite automata. ***Suggested Activities:*** *Discuss on various applications of Deterministic and non-deterministic finite automata.*	15
V	**Moore and Mealy Machines:** Moore Machine, Mealy Machines, Difference between Moore and Mealy machines, Conversion from Moore machine to Mealy machine, Conversion from Mealy machine to Moore machine. ***Suggested Activities:*** *Discuss the applications of (i) Moore Machine in Traffic Light Controller, Elevator Control Systems and Digital Watches (ii) Mealy Machine in Real-Time Control Systems.*	10
VI	**Pushdown Automata:** Pushdown automata, Language accepted by pushdown automata, Difference between pushdown and finite automata, Deterministic Pushdown automata, Non-deterministic Pushdown automata. ***Suggested Activities:*** *Discuss how Pushdown automata are used in parsing and evaluating arithmetic expressions with operator precedence and nested parentheses.*	10
VII	**Turing machine:** Turing machine as a model of computation, Types of Turing machine: Multi-tape, Multi-track, Non-deterministic, Semi-infinite tape. Programming with a Turing machine. ***Suggested Activities:*** *Discuss how Turing machine is used in Artificial Intelligence, Machine Learning and Cryptography.*	10

Keywords/Tags:
Finite Automata and Regular Languages, Finite State Machine, Deterministic and non-deterministic finite automata, Moore and Mealy Machines, Pushdown automata, Turing machine.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. Karibasappa K. G. and Basavaraj S. Anami: Formal Languages and Automata Theory, Wiley, 2011.
2. J. P. Tremblay and R. Manohar, Discrete Mathematical Structures With Applications To Computer Science, McGraw Hill Education, 1st edition, 2017.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, 2nd Ed., Addison-Wesley, 2001.
2. H. R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997.

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-2)		**Class:** Post-Graduate II-Year (Semester – III)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Operation Research (Theory)		
3	Course Type	MMAT0304-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Formulate real life problems into linear programming problem. 2. Apply the simplex method to find an optimal solution. 3. Find optimal solution of transportation and assignment model. 4. Distinguish transportation problem and assignment problem. 5. Formulate and solve linear programming model of two-person zero sum game.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Operation Research: Dr. P. C. Mahalanobis, Dr. C. R. Rao, Dr. Bharat Ramaswami, Dr. Raghavendra Gadagkar	02
II	**Linear Programming Problem:** Basic concepts of linear programming problem, Simplex method and algorithm, Artificial variables technique, Two-phase method, Big-M method. *Suggested Activities: Discuss the applications of Simplex method and Big-M method for solving real world problems.*	13
III	**Duality:** Definition and formulation of the dual problem, Primal-dual relationships, Economic interpretation of the dual, Dual simplex Method, Sensitivity analysis. *Suggested Activities: Discuss the Dual simplex Method and their applications.*	10

Name of BOS: Mathematics
Date: .....

IV	**Transportation Problems:** Mathematical model, Balanced and unbalanced problems, Degeneracy, Optimality conditions, Methods to find starting solution and optimal solution, Algorithm for solving transportation problem, Northwest-Corner method, Least cost method, Vogel approximation method for determination of starting basic solution. *Suggested Activities: Discuss on Northwest-Corner method and Least cost method to solve Transportation Problems.*	13
V	**Assignment Problems:** Mathematical model, Balanced and unbalanced problems, Optimality conditions, Hungarian method, Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem. *Suggested Activities: Discuss on applications of Hungarian method for solving some real-world problems viz. Taxi dispatch, sports refereeing, college project allocation.*	12
VI	**Network Analysis:** Constraints in network, Construction of network, Critical Path Method (CPM), PERT calculation, Resource leveling by network techniques, Advances of network (PERT/CPM). *Suggested Activities: Discuss on applications of Network Analysis in Industry.*	10
VII	Game Theory: Formulation of two-person zero sum games, Solving two-person zero sum games, Games with mixed strategies, Graphical solution procedure, Linear programming solution of games, Non-Linear programming techniques: Kuhn-Tucker conditions, Non-negative constraints. *Suggested Activities: Discuss how Game theory helps analyzing the common resource usage and sustainability strategies.*	15
Keywords/Tags: Linear Programming Problem, Duality, Transportation Problems, Assignment Problems, Game Theory.		

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. Kanti Swarup, P. K. Gupta and Manmohan: Opertions Research, Sultan Chand and Sons, New Delhi, 2014.
2. Guillermo Owen: Game Theory, Emerald Publishing Limited, 4th edition, 2013.
3. S. D. Sharma: Operations Research, Kedar Nath Publication, 2012.
4. Nita H. Shah, Ravi M. Gor and Hardik Soni: Operations Research, PHI Learning Pvt. Ltd., 2007.
5. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali: Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.

Name of BOS: Mathematics
Date: ....

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-1)		**Class:** Post-Graduate II-Year (Semester – IV)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Functional Analysis - II (Theory)		
3	Course Type	MMAT0401-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understanding the inner product spaces, orthogonality and Hillbert spaces. 2. Applying the linear operators in the formulation of differential and integral equations. 3. Analyzing the distinguish between finite and infinite dimensional spaces.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Advanced Abstract Algebra: Dr. T. K. Varadarajan, Dr. R. R. Simha	02
II	Hilbert space, Some properties of Hilbert Space: Schwarz inequality, Parallelogram Law, Polarisation identity. *Suggested Activities: Discuss how Hilbert Space, Schwarz Inequality and Polarization Identity be used in Machine Learning & AI.*	15
III	Convex sets. Orthogonal complements, Pythagoren theorem, Projection Theorem. *Suggested Activities: Discuss the applications of Pythagoren and Projection theorem in Machine Learning and Signal Processing respectively.*	14
IV	Orthonormal sets, Bessel's inequality, Complete orthonormal sets and Paraseval's identity, Gram-Schmidt Orthogonalization process. *Suggested Activities: Discuss the applications of Orthonormal Sets and Gram Schmidt Orthogonalization process in Signal processing and machine learning respectively.*	15
V	The Conjugate Space H*. Riesz Representation Theorem for continuous linear functional on a Hilbert Space. Hilbert adjoint operator and its properties.	14

	Suggested Activities: Discuss the applications of Hilbert adjoint operator in Quantum Mechanics, Signal Processing and Machine Learning.	
VI	Self-adjoint operators, Positive, Normal and Unitary Operators. Weak and strong convergence.	15
	Suggested Activities: Discuss how Normal and Unitary Operators be used in signal processing.	

Keywords/Tags:
Hilbert space, Schwarz inequality, Convex sets, Orthonormal sets, Bessel's inequality, The Conjugate Space H*, Self-adjoint operators.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. E. Kreyzig, Introductory Functional Analysis with applications, John Wiley and Sons, New York, 1978.
2. G. F. Simmons, Introduction to Topology and Modern Analysis Mc Graw Hill, New York, 1983.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. B. Choudhary and Sudarshan Nanda, Functional Analysis with applications, Wiley Eastern Ltd., 2018.
2. P. K. Jain, O. P. Ahuja and Khalil Ahmad, Functional Analysis, New Age International (P) Limited, 1997.
3. K. K. Jha, Functional Analysis and its Applications, Students' Friend, 1986.
4. B. V. Limaye, Functional Analysis, Wiley Eastern Ltd.

Suggested Digital Platforms Web links:
https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25

Suggested Equivalent online courses:
https://nptel.ac.in/courses/111/105/111105037/
https://nptel.ac.in/courses/111/106/111106147/

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-I)		Class: Post-Graduate II-Year (Semester – IV)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Advanced Special Functions - II (Theory)		
3	Course Type	MMAT0402-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Understanding the Hermite polynomials, Pure recurrence relations, Differential recurrence relations. 2. Using the Generating function for Legendre polynomials, Rodrigues formula, Bateman's generating function, Hypergeometric forms of Pn(x), Orthogonality. 3. Analyzing the Laguerre Polynomials Ln(x), Differential Recurrence Relations, Pure Recurrence Relations.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Advanced Special Functions: Dr. C. S. Seshadri, Dr. K. S. Chandrasekharan	02
II	**Legendre polynomials - I:** Generating function for Legendre polynomials, Recurrence relations, Rodrigue's formula, Bateman's generating function, Additional generating functions. ***Suggested Activities:*** *Discuss the applications of Legendre polynomials in other branch of Mathematics.*	15
III	**Legendre polynomials - II:** Hypergeometric forms of $P_n(x)$, Special properties of $P_n(x)$, Some more generating functions, Laplace's first integral form, Orthogonality. ***Suggested Activities:*** *Discuss how Legendre polynomials be used in trajectory planning and path smoothing for autonomous robots and drones.*	14
IV	**Hermite polynomials - I:** Definition of Hermite polynomials $H_n(x)$, Pure recurrence relations, Differential recurrence relations, Rodrigue's formula.	15

	Suggested Activities: Discuss the applications of Hermite polynomials in other branch of Mathematics.	
V	**Hermite polynomials - II:** Other generating functions, Orthogonality, Expansion of polynomials, more generating functions.	14
	Suggested Activities: Discuss how Hermite polynomials be used in Signal Processing and Machine Learning.	
VI	**Laguerre Polynomials:** The Laguerre Polynomials $L_n^{(\alpha)}(x)$, Generating functions, Pure recurrence relations, Differential recurrence relation, Rodrigue's formula, Orthogonality.	15
	Suggested Activities: Discuss how Laguerre polynomials be used in Signal Processing and Communications.	
Keywords/Tags: Legendre polynomials, Hermite polynomials, Laguerre Polynomials.		

Part C – Learning Resources
Text Books, Reference Books, Other Resources
Suggested Readings: **Text Books:** 1. Rainville, E. D.: Special Functions, The Macmillan Co., New York, 1971. 2. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें। **Reference Books:** 1. Lebdev, N. N.: Special Functions and Their Applications, Prentice Hall, Englewood Cliffs, New Jersey, USA 1995. 2. Saran, N., Sharma, S. D. and Trivedi, T. N.: Special Functions with Application, Pragati Prakashan, 2019. **Suggested Digital Platforms Web links:** https://www.eshiksha.mp.gov.in/mpdhe https://epgp.inflibnet.ac.in/Home/ViewSubject

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-1)		**Class:** Post-Graduate II-Year (Semester – IV)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Advanced Discrete Mathematics - II (Theory)		
3	Course Type	MMAT0403-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Test the equivalence of pushdown automata and context free languages. 2. Develop a computational model using Turing machine for the given problem. 3. Design and construct a pushdown automaton and a Turing machine for a computer language. 4. Recognize core concepts relating to the theory of computation and computational models.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Advanced Discrete Mathematics: Dr. C. R. Rao, Dr. Narendra Karmarkar	02
II	**Context free grammars and languages:** Context free grammars, Parse trees, Ambiguities in grammars and languages, Properties of context free languages: Normal forms, Closure, Decision. Pumping lemma for context free languages, Context sensitive languages. ***Suggested Activities:*** *Discuss how Context free grammars are used to model RNA secondary structures and gene regulatory sequences; and in Artificial Intelligence.*	18
III	**Pushdown Automata:** Pushdown automata, Language accepted by pushdown automata, Difference between pushdown and finite automata, Deterministic Pushdown automata, Non-deterministic Pushdown automata. ***Suggested Activities:*** *Discuss how Pushdown automata be used in parsing and evaluating arithmetic expressions with operator precedence and nested parentheses.*	20

IV	**Turing machine:** Turing machine as a model of computation, Types of Turing machine: Multi-tape, Multi-track, Non-deterministic, Semi-infinite tape. Programming with a Turing machine. ***Suggested Activities:*** *Discuss how Turing machine be used in Artificial Intelligence, Machine Learning and Cryptography.*	15
V	**Undecidability:** Recursively enumerable and recursive languages, Undecidable problems about Turing machine: Halting, Post correspondence, Undecidability problems about context free grammars, Rice Theorem. ***Suggested Activities:*** *Discuss the applications of Undecidability in Artificial Intelligence and Machine Learning.*	20

Keywords/Tags:
Context free grammars and languages, Pushdown Automata, Turing machine, Undecidability.

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. Karibasappa K. G. and Basavaraj S. Anami: Formal Languages and Automata Theory, Wiley, 2011.
2. J. P. Tremblay and R. Manohar, Discrete Mathematical Structures With Applications To Computer Science, McGraw Hill Education, 1st edition, 2017.
3. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, 2nd Ed., Addison-Wesley, 2001.
2. H. R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997.
3. J. A. Anderson, Automata Theory with Modern Applications, Cambridge University Press, 2006.

Suggested Digital Platforms Web links:
https://www.eshiksha.mp.gov.in/mpdhe

Suggested Equivalent online courses:
https://nptel.ac.in/courses/106/106/106106049/
https:// nptel.ac.in/courses/106/105/106105196/

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-I)		**Class:** Post-Graduate II-Year (Semester – IV)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Operation Research - II (Theory)		
3	Course Type	MMAT0404-T		
4	Pre-requisite (if any)	To study this course, a student must have had the subject Mathematics at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Learn the constructions of networks of a project and optimal scheduling using CPM and PERT. 2. Compute inventory models on economic lot size system with uniform and non-uniform demand. 3. Formulate and solve linear programming model of two-person zero sum game. 4. Solve nonlinear programming problems using Kuhn-Tucker conditions.		
6	Credit Value	5 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 5 hours per week **Total Lectures:** 75 hours		
Module	Topics	No. of Lectures
I	**Indian Knowledge System:** Contribution and biography of following Indian Mathematicians in Operation Research: Dr. Bharat Ramaswami, Dr. Raghavendra Gadagkar	02
II	**Network Analysis:** Constraints in network, Construction of network, Critical Path Method (CPM), PERT calculation, Resource leveling by network techniques, Advances of network (PERT/CPM). *Suggested Activities: Discuss on applications of Network Analysis in Industry.*	15
III	**Inventory Theory:** Inventory models on economic lot size system with uniform and non-uniform demand, Economic lot size with finite rate of replacement, Simple order level system with constant rate of demand with shortage, Generalized economic lot size model, Multi items deterministic models. *Suggested Activities: Discuss how Inventory theory is used to schedule production, order raw materials, and manage work-in-progress.*	23

IV	**Game Theory:** Formulation of two-person zero sum games, Solving two-person zero sum games, Games with mixed strategies, Graphical solution procedure, Linear programming solution of games, Non-Linear programming techniques: Kuhn-Tucker conditions, Non-negative constraints. ***Suggested Activities:*** *Discuss how Game theory helps analyzing the common resource usage and sustainability strategies.*	20
V	**Extensive Games:** Game tree, Perfect information, Nash and subgame perfect equilibrium, Chance moves, Information set, Incomplete information and perfect recall Various oligopoly models, Coalitional games: Imputation and kernel, Nucleolus and Shapley value. ***Suggested Activities:*** *Discuss how Extensive Games are used to solve some Real-World problems.*	15
Keywords/Tags: Network Analysis, Inventory Theory, Game Theory, Extensive games.		

Part C – Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Text Books:

1. Kanti Swarup, P. K. Gupta and Manmohan: Opertions Research, Sultan Chand and Sons, New Delhi, 2014.
2. Guillermo Owen: Game Theory, Emerald Publishing Limited, 4th edition, 2013.
3. S. D. Sharma: Operations Research, Kedar Nath Publication, 2012.
4. Nita H. Shah, Ravi M. Gor and Hardik Soni: Operations Research, PHI Learning Pvt. Ltd., 2007.
5. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें।

Reference Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali: Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F. S. Hillier and G. J. Lieberman: Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha: Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
4. Prem Kumar Gupta and D. S. Hira: Operations Research-An Introduction, S. Chand & Sons Company Ltd., New Delhi, 1995.

Suggested Digital Platforms Web links:

https://www.eshiksha.mp.gov.in/mpdhe
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25

Suggested Equivalent online courses:

https://nptel.ac.in/courses/110106062/
https://nptel.ac.in/courses/111107128/
https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/275

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-1)		**Class:** Post-Graduate II-Year (Semester – IV)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Writing Skills of Research Report and Research Paper (Theory)		
3	Course Type	VAC (CHM/EESC)		
4	Pre-requisite (if any)	To study this course, a student must have had any subject at Degree level (3 Year Degree Course).		
5	Course Learning Outcomes (CLO)	The course will enable the students to: 1. Recognize the role of clear writing in effective communication of research findings. 2. Explain why documenting research through reports is essential. 3. Identify and sequence the stages involved in writing a research report. 4. Organize content logically within sections of a report. 5. Differentiate between technical, academic, progress, and summary reports. 6. Apply correct grammar, punctuation, and academic language in writing. 7. Structure a research paper into sections such as Abstract, Introduction, Methodology, Results, and Conclusion. 8. Understand the role of research in solving real-world problems. 9. Develop effective presentation skills tailored to scholarly audiences.		
6	Credit Value	2 Credits		
7	Total Marks	Max. Marks: 40 + 60	Min. Passing Marks: 40	

Part B – Content of the Course		
Total No. of Lectures (in hours per week): 2 hours per week **Total Lectures:** 30 hours		
Module	Topics	No. of Lectures
I	Writing Research Report: Significance of Report Writing, Need of Research Report, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Plagiarism Prevention.	15
	Suggested Activities: *Group discussion, Case study analysis, Report structure mapping, Paraphrasing and citation practice.*	

II	**Writing Research Paper and Presentation:** Research Paper Preparation, Types of research papers, Advantages of a Research Paper, Writing a Research Paper, Process of Submission of Research Paper, Presentation of research paper in a conference/seminar/workshop.	15
	Suggested Activities: *Planning Sheet/Template, Classification & Matching Activity, Section-wise Drafting & Peer Review, Journal Search.*	
Keywords/Tags: Research Report Writing, Types of Reports, Format of A Research Paper, Presentation of research paper.		

Part C – Learning Resources
Text Books, Reference Books, Other Resources
Suggested Readings: 1. C. R. Kothari: Research Methodology (Methods and Techniques), New Age International Publishers, 2010. 2. Singh Yogesh Kumar: Fundamental of Research Methodology and Statistics, New age International Publishers, 2006. 3. V. P. Saxena: Research Methodology: Indira publishing House, 2016. 4. मध्यप्रदेश हिन्दी ग्रंथ अकादमी की पुस्तकें। **Suggested Digital Platforms Web links:** https://www.eshiksha.mp.gov.in/mpdhe https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001610/P001713/M020783/ET/1499156968Module19Q1ReportWriting.pdf https://egyankosh.ac.in/bitstream/123456789/39238/1/Unit-5.pdf **Suggested Equivalent online courses:** https://nptel.ac.in/courses/110105091

Part D – Assessment and Evaluation	
Suggested Continuous Evaluation Methods: Maximum Marks: **100** Continuous Comprehensive Evaluation (CCE): **40 Marks** University Exam (UE): **60 Marks**	
Internal Assessment: Continuous Comprehensive Evaluation (CCE)	**Total Marks: 40**
External Assessment: University Exam (UE)	**Total Marks: 60**

Pattern of Marks Distribution THEORY PAPER for NEP PG courses

Assessment and Evaluation

Recommended Continuous Assessment Methods-: **Maximum Marks: 100** Continuous Comprehensive Evaluation (CCE): 40 Marks University Examination: 60 Marks		
Internal Assessment: Continuous Comprehensive Evaluation (CCE):	**Class Test** **Assignment/Presentation**	20 Marks 20 Marks **Total Marks = 40**
External Assessment: University Examination: Time: 3 Hours	**Section (A)**- Five very short answer question (20 words each) **Section (B)**- Five short answer question (200 words each) **Section (C)**- Two long answer question (500 words each)	**02 Marks x 05Questions = 10 Marks** *(All 5 Questions to be attempted)* **06 Marks x 05Questions = 30 Marks** *(5 Questions to be attempted out of total 8 Questions)* **10 Marks x 02 Questions = 20 Marks** *(2 Questions with each having internal choice)* **Total Marks = 60**