Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-1)		**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	CC – 31		
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

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

	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/

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**

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

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	CC – 32		
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

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

	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).	14
	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.*	
VI	Bessel Function: Definition of $J_n(z)$, Bessel's differential equation, Generating function, Bessel's integral with index half and an odd integer.	15
	Suggested Activities: *Discuss the applications of Bessel function in Signal Processing, Control Systems and Medical Imaging.*	

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

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**

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

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 Discrete Mathematics - I (Theory)		
3	Course Type	CC – 33		
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 finite automata, Finite automata, Moore and Mealy Machines.		
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	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.*	08
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. ***Suggested Activities:*** *Discuss the applications of Finite State Machine in Robotics & Automation and Telecommunications.*	20
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.	15

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

	Suggested Activities: *Discuss on various applications of Deterministic and non-deterministic finite automata.*	
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.	20
	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.*	

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

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/

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**

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

Part A – Introduction				
Program: 2-Year Post-Graduate Programme (OPTION-1)		**Class:** Post-Graduate II-Year (Semester – III)	**Year:** 2026	**Session:** 2026-2027
Subject: Mathematics				
1	Course Code			
2	Course Title	Operation Research - I (Theory)		
3	Course Type	CC – 34		
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.		
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	02
II	**Linear Programming Problem:** Basic concepts of linear programming problem, Simplex method and algorithm, Artificial variables technique, Two-phase method, Big-M method.	20
	Suggested Activities: *Discuss the applications of* Simplex method and Big-M method *for solving real world problems.*	
III	**Duality:** Definition and formulation of the dual problem, Primal-dual relationships, Economic interpretation of the dual, Dual simplex Method, Sensitivity analysis.	15
	Suggested Activities: *Discuss the Dual simplex Method and their applications.*	
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-	23

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

	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.	
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.	15
	Suggested Activities: Discuss on applications of Hungarian method for solving some real-world problems viz. Taxi dispatch, sports refereeing, college project allocation.	

Keywords/Tags:
Linear Programming Problem, Duality, Transportation Problems, Assignment Problems.

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

Part D – Assessment and Evaluation

Suggested Continuous Evaluation Methods:

Maximum Marks:	**100**
Continuous Comprehensive Evaluation (CCE):	**40** Marks
University Exam (UE):	**60** Marks

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena

Internal Assessment: Continuous Comprehensive Evaluation (CCE)	**Total Marks: 40**
External Assessment: University Exam (UE)	**Total Marks: 60**

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

Signature of the Chairman (BOS):
Name: Dr. A. K. Saxena