Department
of
Mathematics and Statistics

School of Mathematical and Physical Science

Curriculum Framework
M.Sc.-Mathematics

Based on National Education Policy- 2020

Date of BoS -11/06/2024

Doctor Harisingh Gour Vishwavidyalaya
(A Central University)
Sagar-Madhya Pradesh-470003

Passed by Board of Studies Dated 11/6/24

About the Department:

The Department of Mathematics & Statistics was established with the very inception of the University in the year of 1946. The founder of the university and the founder vice-chancellor Dr. Harisingh Gour had himself appointed Mr. R.B. Rabugunday as the first Head of the Department. Mr. Rabugunday was a scholar of Madras University and a Wrangler of Cambridge tradition.

Curriculum Framework based on National Education Policy-2020

NEP-2020 has conceptualized the idea to develop well rounded competent individuals for making the nation a self-reliant and global leader. In the same spirit, we at Department of Mathematics and Statistics have developed a curriculum framework to encompass the goals of NEP 2020. To this end, we have incorporated choice of subject/disciplines of study, creating academic pathways having constructive combinations of disciplines for study with multiple entry and exit points aswell as focus on **experiential learning** for students by introducing **multidisciplinary and skill enhancement courses** and actual Hand's on training in the recent and trending aspects of

1. **Mathematical Science**

Post Graduate Curriculum Framework

1. **Name of the Programme: (1) Post Graduate Diploma in Mathematics (After exit of one year)**
   (2) Master of Science in Mathematics (After exit of two years)
2. **About the Programme:**
   Mathematics is backbone of all discipline. Aim of this programme is to train young minds to handle the critical problems that occur in Mathematical Sciences as well as in real life.
3. **Objectives of the Programme**
   - To develop students' skills in mathematical science through various tools and techniques.
   - To provide rigorous instruction in fundamental mathematical concepts and skills presented in the context of real-world applications.
   - To introduce students to the enormous diversity and complexity of real life problems in Mathematics.
   - To provide the opportunity to gain familiarity with the applications of mathematics.
4. **Programme Learning Outcomes :**
   The programme learning outcomes are attained by learners through the essential learnings acquired on completion of selected courses of study within a programme. The outcomes and attributes described in qualification descriptors are attained by students through learning acquired on completion of a programme of study.

a) After completion of this program of study the students will have an enhanced knowledge and understanding of mathematics.

b) The Mathematical skills learned through this course will provide analytical understanding for approaching problems that the students encounter in real life situations.

c) Students who will pass out this course be better able to draw inferences that rest on mathematical logics.

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3. Structure of the Programme for: (1) P. G. Diploma in Mathematics (After exit of one year)

Level 8

Semester I				
Nature of Course	**Course Code**	**Course Title**	**Credits**	**Course Designer**
Discipline Specific Major-1	MTS-DSM-121	Abstract Algebra	4	Dr. M.K. Yadav
Discipline Specific Major-2	MTS-DSM-122	Real Analysis-II	4	Dr. R.K. Pandey
Discipline Specific Major-3	MTS-DSM-123	Topology	4	Dr. K. Shrivastava
Multi-Discipline Major	MTS-MDM-121	Operations Research-I	4	Dr. U.K. Khedlekar
Skill Enhancement Course	MTS-SEC-121	Integral Transform	4	Dr. Bhupendra
Semester II				
Nature of Course	**Course Code**	**Course Title**	**Credits**	**Course Designer**
Discipline Specific Major-1	MTS-DSM-221	Complex Analysis	4	Dr. S. Kumar
Discipline Specific Major-2	MTS-DSM-222	Measure Theory	4	Dr. R.K. Pandey
Discipline Specific Major-3	MTS-DSM-223	Partial Differential Equations	4	Dr. M.K. Yadav
Multi-Discipline Major	MTS-MDM-221	**Mathematical Modeling in Biology**	4	
Multi-Discipline Major	MTS-MDM-222	Integral Equation	4	Dr. Bhupendra
Skill Enhancement Course	MTS-SEC-221	Project	4	

Structure of the Programme for: (2) Master of Science in Mathematics (After exit of two years)

Level 9

Semester III				
Nature of Course	**Course Code**	**Course Title**	**Credits**	**Course Designer**
Discipline Specific Major-1	MTS-DSM-321	Functional Analysis	4	Dr. S. Kumar
Discipline Specific Major-2	MTS-DSM-322	**Initial Value & Boundary Value Problems**	4	Dr. M.K. Yadav
Discipline Specific Major-3	MTS-DSM-323	Advanced Abstract Algebra	4	Dr. K. Shrivastava
Multi-Discipline Major	MTS-MDM-321	Numerical Analysis	4	Dr. R.K. Pandey
Skill Enhancement Course	MTS-SEC-321	Project	4	
Semester IV				
Nature of Course	**Course Code**	**Course Title**	**Credits**	**Course Designer**
Discipline Specific Major-1	MTS-DSM-421	Operator Theory	4	Dr. S. Kumar
Discipline Specific Major-2	MTS-DSM-422	Gravitation & Cosmology	4	Dr. M.K. Yadav
Discipline Specific Major-3	MTS-DSM-423	Advanced Discrete Mathematics	4	Dr. K. Shrivastava
Multi-Discipline Major	MTS-MDM-421	Operation Research-II	4	Dr. U.K. Khedlekar
Skill Enhancement Course	MTS-SEC-421	PC Package and Software	4	Prof. D. Shukla
	MTS-SEC-422	Stochastic Process	4	Prof. R.K. Gangele
	MTS-SEC-423	Number Theory	4	Dr. R.K. Pandey

1. **Exit:** (1) Post Graduate Diploma in Mathematics (After exit of one year)

   (2) Master of Science in Mathematics (After exit of two years)

2. **Teaching Learning Approach:**

   Mainly this programme will transact the under given pedagogic approach-

   - Lecture/ Seminar format
   - Demonstration
   - Readings/written assignments and Field Projects
   - Group discussions/tutorial Community visit
   - Project work
   - Field Visit/Survey/Dissertation

3. **Assessment**

   The learner in the programme will be assessed throughout the duration of the programme in a formative and summative evaluations i.e. Mid (I&II) and End Semester examinations. To be eligible to appear in End semester examination a student must appear in Mid semester examinations along with 75 per cent attendance in classroom processes

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Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester I (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem I	MTS-DSM-121	Abstract Algebra	3	1	0	4	IA (Mid)-40 EA (End Sem)- 60	Dr. Kavita Shrivastava

Lectures Hrs.:60

Learning Objectives:

1. To inculcate the basic features of Advanced Abstract algebra.
2. To teach class equation, P-group and Sylow's theorem.
3. To teach solvable and nilpotent groups.
4. To introduce Galois Theory

Course Learning Outcomes:

CO1: After completion of this course the students will be able to understand the composition series.
CO2: Understand Jordan- Holder theorem, solvable groups, nilpotent groups.
CO3: understand field extension and Galois Theory and solvability of polynomial equation using the Galois theory.

Unit Wise Learning Outcomes:

UO1. To learn about Class equation, p-group, Sylow's theorem.
UO2. To learn about normal series, solvable group and nilpotent group.
UO3. To learn about rings.
UO4. To learn about polynomial rings and its.
UO5. To learn about Galois theory and example.

Unit-I Inner Automorphism, Characteristic Subgroup, Conjugate element, Conjugate class of H in G, Class equation, p-groups, Sylow p-subgroups, Sylow theorems.
Unit-II Normal series, subnormal series of group, composition series, Jordan- Holder theorem, solvable groups, nilpotent groups.
Unit- III Rings, Subrings, Sum of two subrings, Product of Rings, Ideals, Sum and product of two Ideals, Prime and maximal ideals, Quotient rings, Homomorphisms and imbedding of rings, Unique factorization domain (UFD), Principal ideal domain (PID), Euclidean domain, Polynomial rings.
Unit-IV Irreducible polynomial, Gauss lemma, Einstein criterion, Adjunction of roots, Algebraic extensions, Algebraically closed fields. Splitting fields, Uniqueness of splitting fields, Normal extensions, Multiple roots, Finite fields, Separable & inseparable extensions.
Unit-V Fields, Subfields, Automorphism groups and fixed fields, Dedekind lemma, Fundamental theorem of Galois theory and example.

Essential Readings:

1. N. Jacobson, Basic Algebra, Vol. I, II & III Hindustan Publishing Company.
2. S. Lang, Algebra, Addision-Wisley.
3. I.S. Luther & IBS Passi, Algebra Vol. I, II & III Narosha Pub. House, New Delhi.
4. M. Artin, Algebra, Prentice- Hall of India, 1991.

Suggested Readings

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra, Cambridge University press.
2. I.N. Herstein, Topic in Algebra, Wiley Eastern, New Delhi.

Essential e-Recourse

1. https://www.cs.columbia.edu/~nadimpalli/data/AAL-Notes.pdf
2. https://archive.nptel.ac.in/courses/111/105/111105112/
3. https://nptel.ac.in/courses/111106113
4. https://www.youtube.com/watch?v=iobTKR4-19o
5. https://www.youtube.com/watch?v=MVojEjXdVgA

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M.Sc. - Semester I (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem-I	MTS-DSM-122	Real Analysis-II	3	1	0	4	IA (Mid) - 40 EA(End Sem)- 60	Dr. R.K.Pandey

Lectures Hrs.:60

Learning Objectives

1. To explain fundamentals of Riemann-Stieltjes integration and its uses.
2. To introduce the Rearrangement of series, Riemann's rearrangement theorem.
3. To explain sequence and series sequence of functions, uniform convergence.
4. To explain the derivation Inverse function and its applications.
5. To explain the concept of extremum in several variable and its applications.

Course Learning Outcomes: This course will enable the students to:

CO1: Learn R-S integrability and its relation with uniform convergence.
CO2: Understand rearrangement and Riemann rearrangement theorem.
CO3: To learn partial derivative, directional derivative and derivative of functions from R^n to R^m .

Unit wise Learning Outcomes: After completion of this course students will be able to:

UO1: Evaluate the integral of a function with respect to an increasing function using the concept of R-S integration. Also students will able to test the convergence of improper integrals.
UO2: Interpret meaning of rearrangement of infinite series and its examples.
UO3: Understand the concepts of uniform and point wise convergence and its consequences in preservation of limit, continuity, integration etc.
UO4: Understand the differentiability of functions of several variables and related theorems e. g. inverse function theorem, implicit function theorem.
UO5: Understand the proof of inverse function theorem and Lagrange multiplier method for extremum prblems.

Unit-I: Definition and existence of Riemann-Stieltjes integral, Conditions for R-S integrability. Properties of the R-S integral, R-S integrability of functions of a function. Improper integrals and test for convergence.
Unit-II: Rearrangements of terms of a series, Riemann's theorem, Dirichlet's theorem. Sequences and series of functions, point wise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence.
Unit-III: Uniform convergence and continuity, uniform convergence and R-S integration; uniform convergence and differentiation, Power series, uniqueness theorem for power series.
Unit-IV: Functions of several variables, derivatives in an open subset of R^n, derivative as linear transformations, directional derivative, chain rule; Partial derivatives, interchange of the order of differentiation, derivatives of higher orders.
Unit-V: Taylor's theorem, inverse function theorem, implicit function theorem, Jacobians, extremum problems with constraints, Lagrange's multiplier method.

Essential Readings:

1. T.M. Apostal: Mathematical analysis, Narosa, 1985.
2. H.L. Royden: Real Analysis, Macmillan (Indian Edition).

Suggested Readings:

1. Walter Rudin: Principles of Mathematical Analysis, McGraw Hill.
2. Terence Tao, Analysis I, Hindustan Book Agency (third edition), 2014.
3. Terence Tao, Analysis II, Springer and Hindustan Book Agency (third edition), 2015.

E- Resource :

1. https://nptel.ac.in/courses/111106053
2. https://nptel.ac.in/courses/111105098
3. https://ocw.mit.edu/courses/18-100a-real-analysis-fall-2020/#~:text=Course%20Description,the%20interchange%20of%20limit%20operations.

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M.Sc. - Semester I (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem I	MTS-DSM-123	Topology	3	1	0	4	IA(Mid)-40 EA(End Exam)-60	Dr. K. Shrivastava

Lectures Hrs: 60

Learning Objectives: This course will enable the students to:

1. To introduce point set topology or general topology.
2. To explain the topological properties of topological spaces.
3. To study product spaces and quotient spaces.
4. To teach Urysohn lemma & Tietze Extension Theorem.
5. To explain the characteristics of topological space.

Course Learning Outcomes:

CO1: After completion of this course, students will know the definitions of standard terms in topology.

CO2: The students will be able to know how to read and write the proofs in topology. They will know a variety of examples and counterexamples in topology and prepare the students to advance courses in topology, geometry, analysis.

CO3: State and prove standard results regarding compact and/or connected topological spaces, and decide whether a simple unseen statement about them is true, providing a proof or counterexample as appropriate.

Unit wise Learning Outcomes: After the completion of the course the students will be able to:

UO 1: Analyze properties of topological spaces and construct various topologies on a general set.

UO 2: Understand the concept of product spaces. Apply the topological concepts and constructions to some chosen real world problems.

UO 3: Understand the concept of quotient spaces

UO 4: Correlate the concept of continuity to compact and connected spaces.

UO 5: Categorize the separation axioms and produce examples for different topological spaces.

Unit-I: Topology on a set and open sets; Examples of topological spaces; Coarse and fine topologies; Basis and sub basis for a topology; Subspace topology; Closed sets and limit points; Continuous maps between topological spaces; Properties of continuous maps; Open and closed maps; Homeomorphisms; Topological embedding; Pasting Lemma.
Unit-II: The product topology on X×Y; The product and box topologies for arbitrary products; Projection maps; Properties of the product topology. Metric on spaces; Uniform metric and topology; Metrizability of the product topology; Sequence Lemma; Sequential definition of continuity; Uniform limit Theorem.
Unit-III: Quotient maps; Open and closed maps; Saturated open sets; Quotient spaces with examples; Properties of quotient spaces. Connected and path connected spaces with examples; Connected and path components; Totally disconnected spaces; Locally connected spaces; Properties of connected and path connected spaces.
Unit-IV: Open covers for spaces; Compact spaces; Tube lemma and compactness for finite products; Finite intersection property and the Tychonoff's theorem; Heine-Borel Theorem; Extreme value theorem; Lebesque number lemma; Uniform continuity theorem; Limit point compactness; Sequential compactness; Local compactness; One-point compactification.
Unit-V: First and second countable spaces with examples; Properties of first and second countable spaces; Dense subsets and separability; Lindelöf spaces. T1 and Hausdorff spaces with examples; Regular and Normal spaces with examples; Properties of Hausdorff, regular and normal spaces; Urysohn's Lemma; Completely regular spaces and their properties; Urysohn metrization theorem; Tietze's extension theorem.

Essential Readings:

1. J.R. Munkres, Topology-A first course, Prentice-Hall of India, New Delhi.

Suggested Readings:

2. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill.
3. K.D. Joshi, Introduction to general Topology, Wiley Eastern.
4. J.L. Kelley, General Topology, Van Nostrand.

Essential e-Resources

1. Link-NPTEL :: Mathematics - Topology
2. Link-An introduction to Point-Set-Topology Part-1 - Course (nptel.ac.in)

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M.Sc. - Semester I (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem-I	MTS-MDM-121	Operations Research-I	3	1	0	4	IA (Mid) - 40 EA(End Sem)- 60	Dr. U. K. Khedlekar

Lectures Hrs.:60

Learning Objectives:

To study the objectives and scope of Operations Research. To learn techniques of Operations Research in business, marketing, assignment etc. To know the properties of convex set, modeling in business and project planning.

Course Learning Outcomes:

CO 1: The inter-displinary course applicable in various businesses.
CO 2: The study of this paper supports insurance, marketing and business strategies.
CO 3: Students capable to design and manage any project.

Unit Wise Learning Outcomes:

UO 1: Learning the Scope of Operations research and its necessity in real life.
UO 2: Learning the method of problem solving using Simplex Method.
UO 3: Learning the control and management of inventory system.
UO 4: Learning the transportation and assignment problem.
UO 5: Learning the project, evaluation and review of techniques.

Unit-I: Operations Research and its scope. Necessity of Operations Research in Industry. Linear Programming Problem, Graphical Method, Simplex method.
Unit-II: - Convex sets, theory of the Simplex method, revised simplex method. Two-Phase simplex method. Big-M method, duality and dual simplex method and sensitivity analysis.
Unit-III: Inventory models, Economic order quantity models with constant rate of demand. Production lot size model with shortage. Buffer stock.
Unit- IV: Transportation problem-initial basic feasible solution. Initial Basic Feasible Solution by North-West Corner Method, Matrix minima method and Vogel's approximation method. Optimal solution, degeneracy in transportation problems. Assignment Problems: Hungarian Method for solution. Crew based problems, Traveling-Salesman (Routing) problems.
Unit- V: Network analysis. Shortest path problems, minimum spanning tree problems. Critical path method, Project evaluation and review technique.

Essential Readings

1. H.A. Taha, Operations Research-An Introduction, Macmillan Publishing INC., New- York.
2. F.S.Hillier& G.J. Lieberman, Introduction to Operations Research, (sixth-edition), McGraw Hill International Edition

Suggested Readings

1. J.C.Pant, Operations Research and optimization, Jain publisher (7th edition)
2. S.D.Sharma. Operations Research, Kedar Nath Ram Sons & co. Publisher Meerut (thirteenth-edition) 2001.
3. Kanti Swarup, P.K. Gupta & Man Mohan, Operations Research., Sultan Chand &sons, New Delhi.

Essential E-Resources

1. https://www.youtube.com/watch?v=BDBhpxRzlml&list=PLWoXNEl-KK1mCv_EL4OdF_-FXryaZ1_N
2. www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf

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M.Sc. - Semester I (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem I	MTS-SEC-121	Integral Transform	3	1	0	4	IA (Mid)-40 EA (End Sem)- 60	Dr. Bhupendra

Lectures Hrs. 60

Learning Objectives:

The aim is to develop the knowledge of different transforms and its applications among students.

Course Learning Outcomes: After completion of this course, student will be able to-

CO1: Have understanding regarding different kind of integral transforms.
CO2: Solve initial value problem and boundary value problem using Laplace Transform.
CO3: Derive Fourier series representation of Periodic functions.

Unit Wise Learning Outcomes:

UO1: Learn about Fourier series.
UO2: Learn about Fourier transform and its properties and will be able to solve the examples based on it.
UO3: Learn about Laplace Transformation and its real life application.
UO4: Learn about Inverse Laplace Transform.
UO5: Discuss the Solution of ordinary differential equation by Laplace transform.

Unit - I: Fourier Series Periodic function, Fourier series formula for periodic functions, Fourier series for odd and even functions, Fourier series for Discontinuous function, Half range Fourier series, Half range cosine series, Half range sine series.
Unit - II: Fourier transforms Definition, Properties evaluation of Fourier and inverse Fourier transforms of functions, Convolution theorem for Fourier transform, Sine and Cosine Fourier transforms, Solving differential equations and integral equations using Fourier Transform.
Unit - III: Laplace Transform Definition of Laplace Transform and examples, Properties of Laplace Transform, Differentiation and Integration properties of Laplace Transform.
Unit - IV: Inverse Laplace Transform Inverse Laplace Transforms and its examples, Convolution theorem and related examples.
Unit - V: Applications of Laplace Transform Solution of ordinary differential equation with constant and variable coefficients by Laplace transforms.

Essential Readings:

1. L. Debnath, Integral transforms and their Applications, CRC Press, New York London- Tokyo, 1995.
2. Erwin Kreyszig, Advanced Engineering Mathematics (8th Edition), Willey Publication, 2010.
3. Wiley & Barrett: Advanced Engineering Mathematics, Mc Graw Hill publication.

Suggested Readings :

1. Schaum's outlines, Laplace Transforms, Murray R. Spiegel.
2. H. K. Dass, Advanced Engineering Mathematics, S. Chand Publication.
3. Ravish R. Singh and Mukul Bhatt, Advanced Engineering Mathematics (4th Edition), McGraw Hill publication, 2018.

E-resources:

1. https://archive.nptel.ac.in/courses/111/102/111102129/
2. https://www.youtube.com/watch?v=sbDuvBc8m8M
3. https://www.youtube.com/watch?v=c2b5Rnlo95I
4. https://www.youtube.com/watch?v=00ZNhBQ1vaQ

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Department of Mathematics and Statistics
Syllabus as per NEP 2020
M.Sc. - Semester II (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem II	MTS - DSM - 221	Complex Analysis	3	1	0	4	IA (Mid) - 40 EA (End Sem) - 60	Dr. S. Kumar

Lecture Hrs. 60

Learning Objectives:

1. Importance of analytic functions in the complex integration.
2. Applications of identity theorem in Maximum modulus principle.
3. Classification of singularities and learn to use Argument principle.
4. Evaluation of real integrals using complex line integration
5. Develop the idea of multi-valued functions and analytic continuation.

Course Learning Outcomes:

CO 1: Learn the fundamental concepts of complex integration and application of Liouville's theorem.
CO 2: Learn Contour integration to evaluate real integrals using residue calculus.
CO 3: Learn integration along a branch cut for multi-valued functions.

Unit-wise Learning Outcomes:

UO 1. Learn about the concept of contour integration.
UO 2. Learn about the importance of Liouville's theorem and its application.
UO 3. Learn about the representation of analytic function in the form of infinite series.
UO 4. Learn about the Möbius transformations and conformal mappings.
UO 5. Learn about the importance of Schwarz reflection principle and Weierstrass-Casorati's theorem.

Unit-I: Analytic functions, Cauchy-Riemann equations, Contour integral, Cauchy's integral theorem, Cauchy's integral formula, higher order derivatives, Morera's theorem, Cauchy's inequality.
Unit-II: Liouville's theorem, Fundamental theorem of algebra, Identity theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem.
Unit-III: Power series, Taylor series, Laurent series, Singularities and their classification, Zeros of analytic functions, Meromorphic functions, Argument principle, Rouche's theorem.
Unit-IV: Residue of function at singular points, Cauchy's residue theorem, Jordan's lemma, Evaluation of proper and improper integrals, Linear transformations, Möbius transformations and its geometric properties, Definitions and examples of Conformal mappings.
Unit-V: Branch point, Branch cut, Branches of a multi-valued function, Integration along a branch cut, Analytic continuation, Schwarz reflection principle, Weierstrass-Casorati's theorem.

Essential Readings:

1. J.E. Brown, R.V. Churchill, Complex Variables and Applications, McGraw-Hill.
2. L.V. Ahlfors, Complex Analysis, McGraw-Hill.
3. J.B. Conway, Functions of One Complex Variable, Narosa Publishing House.

Suggested Readings:

1. S. Ponnusamy, Foundation of complex analysis, Narosa publication.
2. E. C. Titchmarsh, The Theory of Functions, Oxford University Press.
3. H.A. Priestley, Introduction to Complex Analysis, Oxford University Press.

Essential e-Resources:

1. Link-https://nptel.ac.in/courses/111106084/
2. Link-https://ndl.iitkgp.ac.in/document/L9ZmpWxG9HiRaLDQpQJHWBn1kZYf7BhnE4Y5N6ObgLADhA8QYtQM8a1eRBoOZAqzik_FHKiB4c_L4Zmy7PQsdA

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Department of Mathematics and Statistics
Syllabus as per NEP 2020
M.Sc. - Semester II (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem II	MTS – DSM - 222	Measure Theory	3	1	0	4	IA (Mid) - 40 EA (End Sem) - 60	Dr. R.K. Pandey

Lecture Hrs. 60

Learning Objectives:

1. To inculcate the basic features of Lebesgue measures.
2. To acquainted with Lebesgue Integration.
3. To introduce theL^p --space and some inequalities.
4. To teach Completeness of L^p --space and convergence in measure.

Course Learning Outcomes: After completion of this course, the students will be able to

CO 1: Grasp the theory of outer measures, sigma-algebras, and measure spaces, and understand the basic problems measure arising in analysis.

CO 2: Interpret the results in Measure Theory with a critical mind rigorously, whether a given statement in Measure Theory is correct or not.

CO 3: Relate the theoretical structure of Measure Theory as a prerequisite for the future study subjects such as Harmonic Analysis, and Operator Theory

Unit wise Learning Outcomes: After completion of this course successfully, the students will be able to:

UO1: understand the basic concept of measure, the theory of outer measures, sigma-algebras, and understand the basic problems of measure arising in analysis. They conceive the notion of non-measurable sets.

UO2: Interpret the properties of Lebesgue measurable functions, Lebesgue integration Theory, Monotone convergence theorem, and solve basic problems about them.

UO3: Interpret monotone functions on measure spaces, Lebesgue differentiation theorem. Functions of bounded variation, and solve basic problems about them.

UO4: Interpret the results about convex functions, L^p spaces and important inequalities in Measure Theory, and solve basic problems about them.

UO5: conceive the Completeness of Lp-space and convergence in measure and almost uniform convergence, and solve basic problems about them.

Unit-I: Lebesgue outer measure,σ – algebra, measurable sets, regularity, Borel and Lebesgue measurability. Continuity of measures, non-measurable sets, and measurable functions.
Unit - II: Lebesgue integration of measurable non-negative functions, the general Lebesgue integral, Fatou's Lemma, Monotone convergence Theorem, distinction between Reimann and Lebesgue integrals.
Unit -III: Continuity of monotone functions. The Vitali Covering Lemma, The four derivatives, Lebesgue differentiation theorem. Functions of bounded variation, Jordan's Theorem.
Unit- IV: Differentiation and integration. Convex functions, Jensen's inequality. The L^p-spaces, Inequalities of Young, Holder, and Minkowski.
Unit-V: Completeness ofL^p -space, convergence in measure, uniform convergence and almost uniform convergence. Egorff's Theorem.

Essential Readings:

1. H.L. Royden, Real Analysis, Macmillan, Indian Edition New Delhi.
2. Inder K. Rana, An introduction to measure and integration, Macmillan, Narosa Publishing House, India.

Suggested Readings and Link :

1. Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill, New Delhi International student edition.
2. G. de Barra. Measure Theory and Integration, Wiley Eastern (Indian Edition).

Essential e-Resources

1. https://nptel.ac.in/courses/111106161
2. **https://nptel.ac.in/courses/111108135**
3. https://nptel.ac.in/courses/111101100
4. **https://ocw.mit.edu/courses/18-125-measure-and-integration-fall-2003/**

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(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP 2020
M.Sc. - Semester II (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem II	MTS -DSM - 223	Partial Differential Equations	3	1	0	4	IA (Mid) - 40 EA (End Sem) - 60	Dr. M.K.Yadav

Lecture Hrs. 60

Learning Objectives:

1. To develop students' skills in the theory and applications of linear and nonlinear partial differential equations and to provide rigorous instruction to the fundamental concepts and skills.
2. To introduce students the diversity where the partial differential equations be applied and utilised.
3. To provide an advanced treatment of methods for solution of some standard PDEs by method of saperation of variables.

Course Learning Outcomes:

CO 1: Students will have an enhanced knowledge and understanding of linear and nonlinear partial differential equations.

CO 2: The PDE solving skills will provide an insight to students for the applications of PDEs in various fields.

CO 3: Students will be able to apply method of separation of variables in their future research work.

Unit wise Learning Outcomes

UO 1: Students be able to understand that how a partial differential equation originates and will also be able find their solutions by well-established methods.

UO 2: Students will be able to understand Cauchy's method of characteristics, and its applications in various cases.

UO 3: Students will be able to classify II order partial differential equations in parabolic, hyperbolic, and elliptical PDEs.

UO 4: The Reduction to canonical form of a system of linear partial differential equations will be studied in detail.

UO 5: Students will be acquainted with the knowledge of solving non homogeneous PDEs by the method of eigen function expansion, together with the method of separation of variables.

Unit-I: Partial differential equations, Origins of the first order PDEs. PDEs with constant coefficient, Cauchy problem for first order equations. Linear equations of the first order.
Unit-II: Cauchy's method of characteristics. The method of characteristics for PDEs with more than two independent variables. The method of characteristics for a fully nonlinear first-order PDEs.
Unit-III: Charpit's methods for solving first order nonlinear PDEs, The general class of second-order linear PDEs. Classification of second order PDEs in parabolic, hyperbolic and elliptic PDEs.
Unit-IV: Reduction to canonical form of a system of linear partial differential equations. General solution of higher order PDEs with constant coefficients.
Unit-V: Solving nonhomogeneous PDEs by the method of eigenfunction expansion. Method of separation of variables for solving Laplace, Heat and Wave equations.

Essential Readings

1. S. L. Ross, DIFFERENTIAL EQUATIONS: Wiley India Pvt.Ltd , 2010.
2. Ian N. Sneddon, ELEMENTS OF PARTIAL DIFFERENTIAL EQUATIONS, Dover Books on Mathematics, 2006.
3. Stanley J. Farlow, Partial Differential Equations for Scientists and Engineers · 2012
4. I. G. Petrovsky,Lectures on Partial Differential Equations, Dover Publications, 2012.

Suggested Readings

5. P. W. Berg and J. L. Mc Gregor , Elementary Partial Differential Equations. Holden- Day , 1966.
6. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. CHAND & COMPANY LTD, 2013.

e-Resources

1. https://nptel.ac.in/courses/111101153
2. https://nptel.ac.in/courses/111108144

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(Central University)
Department of Mathematics and Statistics
Syllabus as per NEP 2020
M.Sc. Semester-II (Mathematics)

Level & Semester	Course Code	Title ofthe Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem II	**MTS-MDM-221**	**Mathematical Modeling in Biology**	**3**	**1**	**0**	**4**	**IA (Mid) -40 EA (End Sem) - 60**	

Lecture Hrs. 60

Course Learning Outcomes:

CO 1: Students should have an enhanced knowledge and understanding of mathematicalmodeling and stability methods in the analysis of biological systems.

CO 2: The modeling skills provide analytical methods for approaching problems studentsencounter in their future endeavors.

CO 3: Students should be better able to assess biological inferences that rest onmathematical arguments.

Unit wise Learning Outcomes

UO 1: Students should be able to understand that how a real-world problem converted into mathematical form through linear and nonlinear differential equations and will also be able find the long-term behaviors through stability analysis methods.

UO 2: Students should be able to evaluate ecological problems and construct appropriate models. Using these models, they should be able to apply appropriate mathematical toolsand techniques to determine solution behaviour.

UO 3: Students should be able to construct mathematical model for population interactions withdifferent life stages and time delay. They should also be able to find the complex dynamics of biological systems.

UO 4: Students should be able to evaluate the pattern of illness in epidemiological problems through appropriate mathematical models. They should able to determine the basic reproduction number for different infectious diseases.

UO 5: Students should be acquainted with the knowledge of mathematical modeling approachfor various vector-borne diseases and should be able to control the infectious through vaccination strategy in impulsive manner. They should also be able to develop the appropriate strategy for effective pest managements through impulsive differential equations.

Unit I: Basics of Mathematical Modeling: Definition, classification, advantages, limitations, stages of modeling, mathematical models as dynamical systems, phase plane method and qualitative solutions, asymptotic stability.
Unit II: Basic concept of ecology, ecosystems and population biology, applications of differential equations in population biology: growth models, harvesting model, interacting species models.
Unit III: Concept of limit cycles, non-existence of limit cycle, origin of bifurcation, type of bifurcations, Hopf bifurcation theorem, Mathematical Models with stage-structure and time delay,
Unit IV: Modeling of viral infection: Historical aspect of epidemics, SI, SIS and Kermack- Mckendrick SIR models, Basic Reproduction number, SIR model with demographic effect, epidemic models with latent period.
Unit V: Mathematical models for Vector-borne diseases (SI, SIS, SIR models), Impulsivedifferential equation models for pulse vaccination and integrated pest management strategy.

Essential Readings

1. J.D. Murray, Mathematical Biology: I. An Introduction, Springer-Verlag, 2002.
2. H.I. Freedman, Deterministic Mathematical models in Population Ecology, Marcel DekkerInc., New York, 1980.
3. V. Lakshmikanthan, D.D. Bainov and P.S. Simeonov, Theory of Impulsive differentialequations, World Scientific Press, 1989.
4. Maia Martcheva, An Introduction to Mathematical Epidemiology, Springer, 2015

Suggested Readings

1. L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
2. Z. Ma and J. Li, Dynamical Modeling and Analysis of Epidemics, World Scientific, 2009
3. J.N. Kapur, Mathematical Models in Biology and Medicine, East-West Press Private limited.

e-Resources

1. https://nptel.ac.in/courses/111107113
2. https://onlinecourses.nptel.ac.in/noc22_ma20/preview
3. https://onlinecourses.nptel.ac.in/noc20_bt13/preview

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
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Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester II (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L8 Sem. II	MTS -MDM-222	Integral Equation	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. Bhupendra

Lectures Hrs. 60

Learning Objectives:

1. To explain the notion of integral equations.
2. To introduce Volterra and Fredholm integral equation.
3. To explain the various methods to solve integral equations.
4. To explain the notion of Green's function.
5. To explain the singular integral equations.

Course Learning Outcomes:

After completion of this course student will be able to:

CO 1: Obtain the solution of integral equations.
CO 2: Understand the concept of the resolvent kernel approach.
CO 3: Learn about Green's function and its construction.

Unit wise Learning Outcomes:

UO1: Learning about the various types of integral equations.
UO2: Learning about the methods to solve Volterra integral equations.
UO3: Learning about the resolvent kernel and iterated kernel approach to solve Fredholm integral equations.
UO4: Learning about the construction of Green's functions and its use to solve BVP.
UO5: Learning about the singular integral equations and their solutions.

Unit-I: Basic concepts - Relationship between linear differential equations and Volterra integral equations - Resolvent Kernel of Volterra integral equation. Differentiation of some resolvent kernels - Solution of integral equation by Resolvent Kernel - method of successive approximations.
Unit-II: Convolution type equations - Solution of Integro-differential equations with the aid of the Laplace Transformation - Volterra integral equation of the first kind; Euler integrals.
Unit-III: Fredholm integral equations of the second kind. Method of Fredholm Determinants - Iterated Kernels constructing the Resolvent Kernel with the aid of Iterated Kernels - Integral equations with Degenerated Kernels. Hammerstein type equation – characteristic numbers and Eigen function and its properties.
Unit-IV: Green's function, construction of Green's function for ordinary differential equations, special case of Green's function –use of Green's function in the solution of Boundary value problem.
Unit-V: Singular integral equations, Abel's and Cauchy type integral equations, solution of Abel's integral equation, weakly singular kernel, Cauchy principal for integrals, Cauchy type integrals, Hilbert kernel and Hilbert formula.

Essential Readings:

1. Ram P. Kanwal, (2014): Linear Differential Equation, Birkhäuser Boston, MA, 2nd Edition.
2. A.J. Jerri, (1999): Introduction to Integral Equation with Applications", (2nd edition) Wiley Inter science.
3. R. Estrada and Ram P. Kanwal, (2000): Singular Integral Equations, Birkhäuser.

Suggested Readings:

1. C. F. Gerald & P. O. Wheatley (2008): Applied Numerical Analysis (7th edition), Pearson Education, India

E-Resources :

1. https://nptel.ac.in/courses/111104025https://ocw.mit.edu/courses/18-307-integral-equations-spring-2006/
2. National Digital Library.

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester III (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 & Sem. III	MTS-DSM-321	Functional Analysis	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. S. Kumar

Lectures Hrs. 60

Learning Objectives:

1. To introduce Normed space and results on the finite & infinite dimensional spaces.
2. To study properties of Banach space and introduce bounded linear operator on spaces.
3. To discuss the important results related to Inner product and Hilbert spaces.
4. Learning of importance of concepts related to self-adjoint, unitary and normal operators.
5. To discuss the four fundamental theorems for Normed and Banach spaces.

Course Learning Outcomes:

After completion of this course student will be able to:

CO 1: Learn the fundamental concepts of Normed and Banach spaces.
CO 2: Know the importance of inner product and Hilbert spaces in functional analysis.
CO 3: Understand the application of Hahn-Banach theorem for real vector spaces.

Unit-wise Learning Outcomes:

UO1: Learning of the concepts related to normed space and compactness in finite dimensional space.
UO2: Learning of the importance of Banach space and linear operators in functional analysis.
UO3: Learning of the properties related to inner product space and orthogonal complements.
UO4: Learning of the representation of bounded linear functional and operators on Hilbert space.
UO5: Learning of the applications of uniform boundedness principle in functional analysis.

Unit-I: Normed spaces, examples of normed spaces, Quotient spaces, finite dimensional normed spaces and subspaces, Equivalent norms, Schauder basis and separability, Heine-Borel theorem, Riesz's Lemma, finite dimensional normed spaces and compactness.
Unit-II: Banach spaces, examples of Banach spaces, properties of Banach spaces, Baire category theorem, bounded and continuous linear operators, bounded linear functional, normed spaces of operators, Dual spaces.
Unit-III: Inner product spaces, properties of inner product space, Hilbert spaces, best approximation theorems, Orthogonal complements, projection theorem, Orthonormal sets, Bessel's inequality.
Unit-IV: Total orthonormal sets, Parseval's identity, Riesz-Fischer theorem, Riesz's representation theorem, Hilbert-adjoint operator, self-adjoint, unitary and normal operators, reflexive spaces.
Unit-V: Hahn-Banach theorem for real and complex vector spaces, Hahn-Banach theorem for normed spaces, Uniform boundedness theorem, open mapping and closed graph theorems.

Essential Readings:

1. E. Kreyszig, (1978): Introductory Functional Analysis with Applications, John Wiley & Sons, New York.
2. M. Thamban Nair, (1963): Functional Analysis A First Course, PHI Learning Private Limited, India.

Suggested Readings:

1. D. Somasundaram, (2006): A First Course in Functional Analysis, Narosa Publishing House, India.
2. G.F. Simmons, (1963): Introduction to Topology and Modern Analysis, McGraw-Hill, New York.
3. S. Ponnusamy, (2002): Foundations of Functional Analysis, Narosa Publishing House, India.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ma25/preview
2. https://video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=functional+analysis+video&type=C211US660D20151202#id=9&vid=18e3a1a48f526a6289f691c4e8f869bd&action=click
3. https://video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=functional+analysis+video&type=C211US660D20151202#id=1&vid=15a72ecb1bfb9dc83a7df71ac1b585cd&action=click
4. National Digital Library

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester III (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 & Semester III	MTS-DSM-322	Initial Value and Boundary Value Problems	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. M.K. Yadav

Lectures Hrs. 60

Learning Objectives:

1. To learn how to frame and solve Initial value problems.
2. To solve problems related to existence and uniqueness.
3. To explore SLBVP.
4. To solve problems related to BVP in rectangular coordinates.
5. To understand Boundary-Value Problems in other coordinate systems.

Course Learning Outcomes:

After completion of this course students will be able to:

CO1: Understand basic concepts of Boundary value problem.
CO2: Understand development about existence and uniqueness.
CO3: Learn the two-point Boundary value problem.

Unit Wise Learning Outcomes:

UO1: Learning about specification of linear and nonlinear models.
UO2: Learning about IVP for ODE.
UO3: Learning about orthogonal series expansion.
UO4: Learning about higher dimension problems.
UO5: Learning about spherical coordinates.

Unit-I: Initial-value and Boundary-value problems, Homogeneous equations, non-homogeneous equations. Green's functions: Initial-value problems and Boundary-value problems. Linear models: Initial-value problems, Spring/Mass Systems: Free undamped motion Spring/Mass Systems: Free damped motion Spring/Mass Systems: driven motion, Linear models: Boundary-value problems, Nonlinear models.
Unit-II: Initial value problem for ODEs, methods of existence and uniqueness of the solution of the ordinary differential equation of the first order and their examples.
Unit-III: Two-point Boundary- value problems, Sturm Liouville BVP, Non-homogeneous BVP, Singular Sturm Liouville BVP.
Unit-IV: Boundary-value problems in rectangular coordinates: Separable partial differential equations, classical PDEs and Boundary-value problems, Heat, Wave and Laplace's equation, Non-homogeneous BVP involving PDEs, Orthogonal series expansions, Higher-dimensional problems.
Unit-V: Boundary-value problems in other coordinate systems: Laplacian in polar coordinates, Steady temperatures in a circular plate, steady temperatures in a semicircular plate, Polar and Cylindrical coordinates, Radial vibrations of a circular membrane, Steady temperatures in a circular cylinder, Spherical coordinates, Steady temperatures in a sphere.

Essential Readings:

1. V. I. Smirnov, (1964): A course of higher Mathematics, Vol. IV, (Translation), Pergamon Press, Oxford.
2. C. Corduneanu, (1991): Integral equations & Applications, Cambridge University Press, Cambridge.

Suggested Readings:

1. A. M. Wazwaz, (2015): A first course in Integral Equations, 2nd edition, World Scientific, Singapore.
2. S.G. Mikhlin, (1965): Integral equations, (Vol. 4) (Translation), Pergamon Press, London.
3. L. G. Chambers, (1976): Integral equations- A Short Course London, International Textbook Company Limited.
4. B. P. Parashar, (2008): Differential & Integral Equations, CBS Publishers & Distribution, Delhi.

E-Resource : National Digital Library

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
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Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester III (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 Sem. III	MTS-DSM-323	Advanced Abstract Algebra	3	1	0	4	IA (Mid) – 40 EA (End Sem) –60	Dr. Kavita Shrivastava

Lectures Hrs. 60

Learning Objectives:

1. To inculcate the basic features of advanced abstract algebra.
2. To teach canonical forms and primary decomposition theorem.
3. To acquainted with Module theory.
4. To introduce Noetherian and Artinian modules.
5. To teach finitely generated modules over a PID

Course Learning Outcomes:

After completion of this course the students will be able to:

CO1: Understand the canonical forms and primary decomposition theorem.
CO2: Know the Module theory, Noetherian and Artinian modules.
CO3: Understand the finitely generated modules over a PID and rational canonical forms.

Unit Wise Learning Outcomes:

UO1: Learning about canonical forms.
UO2: Learning about Modules, Quotient modules.
UO3: Learning about free modules, Noetherian, Artinian modules and rings.
UO4: Learning about uniform modules, Noether-Laskar theorem.
UO5: Learning about fundamental theorem of finitely generated modules over a principal ideal domain and its applications.

Unit-I: Canonical forms-similarity of linear transformation, Invariant spaces, reduction to triangular forms, Nilpotent transformations, index of nilpotency, invariants of a nilpotent transformation, primary decomposition theorem.
Unit-II: Cyclic modules, sum of modules, internal and external direct sum, direct product, quotient modules, Exact sequences of modules, semi simple modules.
Unit-III: Schur's lemma, free modules, Noetherian & Artinian modules and rings, ring of triangular matrices which is right Noetherian but not left Noetherian, Hilbert basis theorem, Wedderburn-Artin theorem.
Unit-IV: Uniform modules, primary module, Noether-Laskar theorem, Smith normal forms over a principle ideal domain and rank.
Unit-V: Fundamental theorem of finitely generated modules over a principal ideal domain and its applications to finitely generated abelian groups, Rational canonical forms.

Essential Readings:

1. N. Jacobson : Basic Algebra, Vol. I, II & III, Hindustan Publishing Company.
2. S. Lang : Algebra, Addition-Wisley.
3. I S. Luther & IBS Passi : Algebra, Vol. I, II & III, Narosha Pub. House, New Delhi.
4. M. Artin, (1991): Algebra, Prentice- Hall of India.

Suggested Readings:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, (2012): Basic Abstract Algebra, Cambridge University press.
2. I.N. Herstein: Topic in Algebra, Wiley Eastern, New Delhi.

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester III (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L 9 Sem. III	MTS-MDM-321	Numerical Analysis	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. R. K. Pandey

Lectures Hrs. 60

Learning Objectives:

1. To explain the construction of numerical methods for the solution of algebraic and transcendental equations of systems.
2. To introduce stability and convergence criteria for various numerical methods.
3. To explain the relaxation and iterative methods and their convergence criteria for system of linear equations.
4. To explain the procedure to construct numerical methods for numerical integration and its uses to integrate differential equations.
5. To explain the numerical algorithms/schemes to solve the ordinary and partial differential equations.

Course Learning Outcomes: This course will enable the students to:

CO1: Obtain numerical solutions of algebraic and transcendental equations.
CO2: Understand the concept of order of accuracy of the methods.
CO3: Learn about interpolating methods to find numerical solutions of IBP in differential equations.

Unit wise Learning Outcomes: After completion of this course students will be able to:

UO1: Know to the derivation of numerical methods for the approximate solution of algebraic and transcendental equations.
UO2: Know the alternative numerical method to find the solutions of system of linear equations and able to know the ways to check the accuracy of the solutions.
UO3: Interpret the numerical quadrature rules and its applications. They will also be aware with the utility of finite difference method to solve the second order differential equations.
UO4: Know the derivation of numerical methods and multistep method to solve ODE and PDE.
UO5: Understand applications of various numerical methods to find the solution of differential equations.

Unit-I: Solution of algebraic and transcendental equations, Nonlinear equations in one variable, Fixed point iterative methods, convergence criterion, Aitken's $\Delta 2$ – process for acceleration the convergence of Fixed-point iterative method, Newton–Raphson's method, convergence criterion, order and rate of convergence.
Unit-II: Linear and nonlinear system of equations. Indirect methods: Jacobi and Gauss Seidel iterative methods with convergence criterion. successive over relaxation. Interpolation: Lagrange, Hermite interpolation.
Unit-III: Numerical Integration, Newton-Cotes formulae, construction of Gaussian quadrature formulae, error estimates, Radau and Lobatto quadrature rules, Gauss-Legendre, Gauss-Chebeshev formulas, Gauss Leguerre, Gauss Hermite quadrature rules. Spline intergation – Integration over rectangular and general quadrilateral areas and multiple integration with variable limits. Extrapolation methods and their applications.
Unit-IV: Numerical solution of ordinary differential equations: Initial value problems. Euler and backward Euler Method, Higher order Taylor methods, Modified Euler's method. Runge-Kutta methods of second and fourth order. Stability and convergence of single step method, absolute stability, A-stability, zero-stability. Region of absolute stability of explicit and implicit Runge-Kutta methods.
Unit-V: Boundary - Value problems, finite difference and cubic spline methods for ordinary differential equations. Numerical solution of partial differential equations using finite difference method. Basic concepts of finite element method, weak formulation of BVP, Ritz Method.

Essential Readings:

1. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.
2. Endere Suli and David F. Meyer, (2003) An introduction to numerical analysis, Cambridge University Press; Illustrated edition.
3. M.K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th edition), New Age International Publishers.
4. Robert J. Schilling & Sandra L. Harris (1999). Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole.

Suggested Readings:

1. S. S. Sastry, (2010) Introductory Methods of Numerical Analysis, PHI Learning Private Limited, New Delhi.
2. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India
3. Melvin J. Maron, (1982) Numerical Analysis A Practical Approach, Macmillan Publishing Company Inc., New York.

E-Resource :

1. Numerical methods - Course (nptel.ac.in) Introduction to Numerical Methods | Mathematics | MIT OpenCourseWare

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
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Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester IV (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 & Sem. IV	MTS-DSM-421	Operator Theory	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. S. Kumar

Lectures Hrs. 60

Learning Objectives:

1. To know importance of compact operators in functional analysis.
2. To discuss spectral theory in the finite dimensional spaces.
3. To explain properties of spectral theory for bounded linear operators.
4. To provide applications of spectral mapping theorem for polynomials.
5. To discuss importance of Gelfand's theory for commutative Banach Algebras.

Course Learning Outcomes: After completion of this course a students will be able to:

CO 1: Learn the fundamental concept of spectrum of linear operator.
CO 2: Learn resolvent equation and spectral radius.
CO 3: Learn the properties of Banach Algebras.

Unit-wise Learning Outcomes:

UO1: Learn about the classification of spectrum of linear operator.
UO2: Know about the importance of spectral theory for bounded linear operators.
UO3: Understand about the spectral mapping theorem for polynomials.
UO4: Learn about the Normed and Banach algebras.
UO5: Learn about the Gelfand's theory for commutative Banach algebras.

Unit-I: Representation of dual spaces, Reflexivity and weak convergence, Space of compact operators, Properties of compact operators.
Unit-II: Spectral theory in finite dimensional normed spaces, Resolvent set and spectrum of linear operator, Classification of spectrum of linear operator.
Unit-III: Spectral properties of bounded linear operators, Resolvent equation, Commutativity.
Unit-IV: Spectral radius and spectral mapping theorem for polynomials, Analytic vector-valued functions, Normed and Banach Algebras.
Unit-V: Properties of Banach Algebras, Gelfand's theory of commutative Banach Algebras.

Essential Readings:

1 E. Kreyszig,(1978): Introductory Functional Analysis with Applications, John Wiley & Sons, New York.
2 M. Thamban Nair,(2014): Functional Analysis A First Course, PHI Learning Private Limited, India.
3 D. Somasundaram,(2006): A First Course in Functional Analysis, Narosa Publishing House, India.

Suggested Readings:

4. G. Bachman, L. Narici,(1966): Functional analysis, Academic Press, New York.
5. G.F. Simmons,(1963): Introduction to Topology and Modern Analysis, McGraw-Hill, New York.

E-Resources:

1. https://video.search.yahoo.com/search/video;_ylt=AwrO_GwcAVJlUGgfQv_7w8QF;_ylu=c2VjA3NlYXJjaAR2dGlkAw--;_ylc=X1MDOTY3ODEzMDcEX3IDMgRmcgNtY2FmZWUEZnIyA3A6cyx2OnYsbTpzYixyZ246dG9wBGdwcmlkAzlwUFM5NGFaU25hRGZ1dEVPTTgybEEEbl9yc2x0AzAEbl9zdWdnAzAEb3JpZ2luA3ZpZGVvLnNlYXJjaC55YWhvby5jb20EcG9zAzAEcHFzdHIDBHBxc3RybAMwBHFzdHJsAzIxBHF1ZXJ5A09wZXJhdG9yJTIwVGhlb3J5JTIwTlBURUwEdF9zdG1wAzE2OTk4NzMxNjI-?p=Operator+Theory+NPTEL&ei=UTF-8&fr2=p%3As%2Cv%3Av%2Cm%3Asb%2Crgn%3Atop&fr=mcafee&type=C211US660D20151202#id=1&vid=3544b5958b631048d6e5b23feb273f46&action=view
2. https://video.search.yahoo.com/search/video;_ylt=AwrO_GwcAVJlUGgfQv_7w8QF;_ylu=c2VjA3NlYXJjaAR2dGlkAw--;_ylc=X1MDOTY3ODEzMDcEX3IDMgRmcgNtY2FmZWUEZnIyA3A6cyx2OnYsbTpzYixyZ246dG9wBGdwcmlkAzlwUFM5NGFaU25hRGZ1dEVPTTgybEEEbl9yc2x0AzAEbl9zdWdnAzAEb3JpZ2luA3ZpZGVvLnNlYXJjaC55YWhvby5jb20EcG9zAzAEcHFzdHIDBHBxc3RybAMwBHFzdHJsAzIxBHF1ZXJ5A09wZXJhdG9yJTIwVGhlb3J5JTIwTlBURUwEdF9zdG1wAzE2OTk4NzMxNjI-?p=Operator+Theory+NPTEL&ei=UTF-8&fr2=p%3As%2Cv%3Av%2Cm%3Asb%2Crgn%3Atop&fr=mcafee&type=C211US660D20151202#id=2&vid=7956d1d526ab5e32be2d7b5707fdfa5a5&action=view

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester IV (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 Semester IV	MTS-DSM-422	Gravitation & Cosmology	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. M.K. Yadav

Lectures Hrs. 60

Learning Objectives:

1. To learn about Christoffel symbols.
2. To solve problems related to Kruskal-Szekeres Coordinates.
3. To explore Eienstein field equations.
4. To solve problems related to Cosmological models.
5. To aware about Friedmann-Robertson-Walker Cosmological model.

Course Learning Outcomes:

After completion of this course the students will be able to:

CO1: Understand tensor calculus methodologies.
CO2: Understand Robertson-Walker Cosmological model.
CO3: Understand static and non static models.

Unit Wise Learning Outcomes:

UO1: Learning about Bianchi identities.
UO2: Understanding about Singularities in Schwarzschild line element
UO3: Learning about, Energy- momentum tensor.
UO4: Understanding about Einstein's field equation with cosmological term
UO5: Learning about Weyl's postulate.

Unit-I: Tensor calculus, Transformation law of a tensor, contraction, quotient law, Metric tensor and Riemann Space, Christoffel symbols, covariant differentiation, Geodesics, Riemannian curvature tensor, covariant curvature tensor, Bianchi identities, Lie derivative, principle of equivalence, principle of general covariance, Mach's principle, Geodesic postulate.
Unit-II: Newtonian approximation of equation of motion, Einstein's field equation for matter and empty space, Reduction of Einstein's field equation to Poisson's equation. Schwarzschild exterior metric and its isotropic form, Singularities in Schwarzschild line element, Kruskal-Szekeres coordinates. Derivation of the formula GM = c^2m, Three crucial tests in general relativity and their detailed descriptions.
Unit- III: Analogues of Kepler's laws in general relativity, Trace of Einstein tensor, Energy- momentum tensor and its expression for perfect fluid, Schwarzschild interior metric and boundary condition, action principle, Derivation of Einstein field equation from variational principal, Energy momentum pseudo tensor.
Unit-IV: Einstein's field equation with cosmological term. Static cosmological models (Einstein & de-Sitter models) with physical and geometrical properties. Non static form of de-Sitter line-element and red shift in this metric,
Unit-V: Einstein space, Hubble's law, Weyl's postulate. Derivation of Robertson-Walker metric. Friedmann Robertson-Walker cosmological model.

Essential Readings:

1. Narlikar, J. V. year, An Introduction to Relativity, Cambridge University Press, New Delhi.
2. Roy, S.R. and Bali, R.,year Theory of Relativity, Jaipur Publishing House, Jaipur Reference Books

Suggested Readings:

1. Eisenhart, L.P. (1949): Riemannian Geometry, Princeton University Press, Princeton
2. Einstein, A. (1955): The meaning of Relativity, Princeton University Press Princeton, New Jersey.
3. Narlikar, J. V. (2002): Introduction to Cosmology, Cambridge University Press, Cambridge

E-Resource: National Digital Library

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester IV (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L 9 Sem. IV	MTS-DSM-423	Advanced Discrete Mathematics	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. Kavita Shrivastava

Lectures Hrs. 60

Learning Objectives:

1. To achieve command over fundamental definitions and concepts of Boolean Algebra.
2. To explore and exercise the concept of logic.
3. To apply theoretical knowledge acquired for solving realistic problems in real life.

Course Learning Outcomes: After completion of this course the students will be able to:

CO1: Understanding about theory of discrete objects, starting with relations and partially ordered sets.
CO2: Understanding about recurrence relations, generating function and operations there on.
CO3: Understanding of graphs and trees, useful in developing software.
CO4: Understanding about basic knowledge on models of automata theory and the corresponding formal languages.

Unit Wise Learning Outcomes:

UO1: Learning about Partial ordered set, Hasse diagrams, Lattice
UO2: Learning about basic fundamentals of Boolean algebra.
UO3: Understanding about various structure of graph theory.
UO4: Awareness about Grammar and Languages useful in computer science.
UO5: Awareness about Computability Theory and its applications.

Unit I: Formal Logic: statement, symbolic representation, tautologies, quantifiers, predicates and validity, propositional logic. Lattices: relations, equivalent relation, partial order relations, Hasse diagram, Maximal and Minimal elements, lower and upper bound, Joint and meet in poset, Lattices as partially ordered sets and their properties. Lattices and algebraic systems. Sub lattices, some special lattices for example complimented and distributive lattices.
Unit II: Boolean Algebra: Boolean algebra as Lattices. Various Boolean identities, Join-irreducible elements. Atoms and Minterms. Boolean forms and their equivalence. Boolean expressions, Boolean functions, Applications of Boolean algebra to switching theory (using AND, OR and NOT gates).
Unit III: Graph Theory – Definition of (undirected) graphs, Paths, Circuits, Cycles and Subgroups. Induced Subgraphs. Degree of a vertex. Connectivity. Planar graphs and their properties. Trees, Euler's Formula for connected Planar graphs, Complete graph and Complete Bipartite graphs. Kurtowski's Theorem (statement only) and its use. Spanning Trees, cut-sets, minimal spanning trees and Kruskal's Algorithm. Matrix representations of graphs. Euler's theorem on the existence of Eulerian paths and Circuits, Directed graphs. Indegree and Outdegree of a vertex. Weighted undirected graphs. Dijkstra's algorithm.
Unit IV: Grammar and Languages — Phrase structure grammars. rewriting rules. Derivations, sentential forms. Language generated by grammar. Regular, Context free and Context sensitive Regular expressions and the Pumping Lemma. Notions of syntax analysis. Polish notations. Conversion of Infix, expressions to Polish Notations.
Unit V: Introductory Computability Theory – Finite state machines and their transition, table diagrams. Equivalence of finite state machines. Reduced machines. Finite automata. Acceptors. Non-deterministic finite automata and equivalence of its power to that of Deterministic Finite Automata, Moore and Mealy Machines.

Essential Readings :

1. J.P.Tremblay & R.Manohar, (1997) : Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill, New Delhi.
2. Narsingh Deo: Graph Theory with applications, Prentice-Hall, New Delhi.

Suggested Readings :

1. C.L.Liu: Elements of Discrete Mathematics, McGraw Hill, New Delhi.
2. J.L.Gresting: Mathematical Structures for Computer Science, Computer Science Press, New York.
3. K.D. Joshi: Foundations in Discrete Mathematics, New Age Publication, New Delhi.

E-Resource:

1. https://www.youtube.com/watch?v=lJ98odiHWso&list=PLyqSpQzTE6M_f9q2YVF0rx9oSO_UAteS0https://www.youtube.com/watch?v=WW7YO0b4QHs&list=PLEAYkSg4uSQ2Wfc_l4QEZUSRdx2ZcFzi
2. National Digital Library

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester IV (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 Sem. IV	MTS–MDM- 421	Operations Research –II	3	1	0	4	IA (Mid) – 40 EA (End Sem) – 60	Dr. U.K. Khedlekar

Lectures Hrs. 60

Learning Objectives:

1. To study the scope of Queuing theory, Game theory and linear programming problems.
2. To learn the use of these techniques in business, marketing, task assignments.
3. To aware about the properties of dynamic programming and the classical optimization.

Course Learning Outcomes: After completion of this course student will be able to:

CO 1: Apply tools and techniques of this course in solving problems of real life.
CO 2: To design insurance, marketing and business strategies.
CO 3: To design and manage any project based on the queuing model and game theory.

Unit Wise Learning Outcomes:

UO 1: Learning of the concept of game theory and finding graphical solution of LPP.
UO 2: Learning of the Steady-state solutions of Markovian queuing models.
UO 3: Understanding of the integer linear programming using various techniques.
UO 4: Learning of the problems using classical optimization method.
UO 5: Awareness of the Dynamic programming problems.

Unit-I: Games Theory, Two-person zero-sum game, game with mixed strategies. Principle of dominance, rectangular gar Graphical solution by linear programming.
Unit-II: Elementary queuing models. Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, Queuing models M/M/C.
Unit-III: Integer linear programming: Pure and mixed, Gomory's cutting plane method, branch and bound method.
Unit-IV: Classical optimization: Unconstrained problem of maxima and minima (necessary & sufficient condition). Kuhn-Tucker conditions for constrained problem, Wolfe method for quadratic programming problem.
Unit-V: Dynamic programming: Minimum path problems, problems on single additive constraints, additive separable return, single multiplicative constraints and additive separable return.

Essential Readings:

1. H.A. Taha: Operations Research- An Introduction, Macmillan publishing INC., New-York.
2. F. S. Hillier & G.J. Lieberman, (2001) Introduction to Operations Research, (Sixth- edition). McGraw Hill International Edition.
3. S. D. Sharma, (2009): Operations Research, Kedar Nath Ram Sons co. Meerut thirteenth – edition.
4. Kanti Swarup, P.K. Gupta & Man Mohan, (2220): Operations Research. Sultan Chand & sons, New Delhi.

Suggested Readings:

1. P.K. Gupta and D.S. Hira, (2004): Operations Research, S. Chand and company, New Delhi.
2. B.S. Goel, S.K. Mittal and S.K. Pundir, (2018): Operations Research, Pragati Prakashen, Meerut.

E-Resource:

1. Tutorials in operations research, Johnson M. (ed.), Informs 2006, ISBN: 1877640204
   Link- http://booksdl.org/get.php?md5=3A0D90ED898146B31705617AF557441C
2. Video on Game Theory in Operation research USING mini max principle, odds method, dominance method
   https://www.youtube.com/watch?v=LV7TLjIFBYY
3. National Digital Library

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester IV (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 Semester IV	MTS–SEC- 421	PC Package and Software	3	1	0	4	IA(Mid) – 40 EA(End Sem) – 60	Prof. Diwakar Shukla

Lectures Hrs. 60

Learning Objectives:
1. To learn the basics of MS-Word, Ms-Excel and Ms Power point
2. To learn the use of mathematical and statistical Softwares

Course Learning Outcomes:
After completion of this course the students will be able to
CO1: Type the text on a computer system.
CO2: Analyze the data and presentation of data using graphs and charts.

Unit Wise Learning Outcomes:
UO1: Learning of various commands and functions in existing in MS Word.
UO2: Learning of writing a text and its editing.
UO3: Capacity of data analysis and drawing graph, charts.
UO4: Learning of writing interpretation and data analysis outcome presentation.
UO5: Understanding the use of some specific mathematical and statistical softwares.

UNIT I: MS-Word: Introduction, word processing, advantages of word processing, creating, saving and editing a document: selecting, deleting, replacing text, copying text to another file. formatting text and paragraph: using the font Dialog Box, paragraph formatting using bullets and numbering in paragraphs, checking Spelling, Line spacing, margins, inserting Space before and after paragraph.
UNIT II : Defining Tabs: using Ruler Bar, mouse and tabs Dialog Box. Enhancing document: inserting page breaks, adding border, opening and closing Toolbars, using Header and Footers in the document. creating and formatting tables: changing row height, inserting columns, merging cells calculations in a table, sorting text, using graphics, using the drawing toolbar using word art, mail merge: definition, a practical example of mail-merge, creating charts.
UNIT III: MS Excel: Introduction, definition Excel screen parts of worksheet, entering information: numbers, formula, editing data in a cell, Excel functions, using a range with SUM, moving and copying data, Inserting and deleting row and columns in the worksheet, using the format cells Dialog box, using chart wizard to create a chart, naming ranges, classification of Excel functions, performing what if analysis with data table.
UNIT IV: Power Point - Introduction, Slide show, Formatting, creating a presentation, Inserting Clip Arts, adding objects, applying transitions, Animation effects, formatting and checking text, modifying visual elements, preparing a complete presentation, Case studies.
UNIT V: Mathematical Software, MATLAB, SPSS, Mathematical input output statement, looping and branching, control statements in mathematical/statistical softwares.

Essential Readings:

1. R.K. Taxli,PC Software for Windows- Made Simple, TMH Publication.
2. Satish Jain, PC Software-Made Simple, BPB Publication
3. Lambert Joan, Microsoft Office -2016, Step by Step, Published by Microsoft Press .

Suggested Readings:

1. Will Train, Gini Corter and Annette Marquis, Microsoft Office, BPB Publication
2. S.S. Shrivastava, MS Office , Laxmi Publication.

Essential e-Resources:
1. https://www.keynotesupport.com/menu-pc-shtml
2. National Digital Library

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
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Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester IV (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 Semester IV	MTS–SEC- 422	Stochastic Processes	3	1	0	4	IA(Mid) – 40 EA(End Sem) – 60	Prof. R.K. Gangele

Lectures Hrs. 60

Learning Objectives:

1. To study concept of stochastic process
2. To study Markov chains and their applications
3. To learn applications of Markov process, Brownian motion process, and Wiener process

Course Learning Outcomes:

After completion of this course student will be able to learn

CO1: Stochastic process scenario and its applications in real life.
CO2: Stochastic model formation for the real probabilistic situations.

Unit-Wise learning outcome:

UO1: Understanding the basics of Stochastic Process
UO2: Learning about fundamentals of Markov chains and their applications.
UO3: Understanding of the transition probability matrix
UO4: Learning and application of stochastic birth and death processes.
UO5: Learning about various Markov processes

UNIT I: Introduction to Stochastic process, classification of Stochastic process as per state and time domain into discrete and continuous time, discrete and continuous space. Application of Stochastic process, strongly and weakly stochastics process.
UNIT II: Markov chains: Definition and examples of Markov chains. Transition probability matrix, classification of states, communicating classes, recurrence and non-recurrence, irreducibility, stationary distribution and its application.
UNIT III: Chapman-Kolmogorov equation, n-step transition probability matrix and their limit. Random Walk and Gambler's ruin problem
UNIT IV: Statistical inference for Markov chains: Estimation of Transition probabilities. Discrete space continuous time Markov processes: Poisson process, Simple birth process, simple death process, simple birth-death process.
UNIT V: Continuous state continuous time Markov processes, Brownian motion process, Wiener process and its properties.

Essential Readings:

1. J. Medi, Stochastic Processes, 3rd Ed, Wiley Eastern Ltd., 2012

Suggested Reading:

1. B.R. Bhat, Stochastic Models: Analysis and Applications, New Age International India, 2000

E-Resource: National Digital Library

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DOCTOR HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A Central University)
Department of Mathematics and Statistics
Syllabus as per NEP-2020
M.Sc. - Semester IV (Mathematics)

Level & Semester	Course Code	Title of Course	Credits				Marks	Course Designer
			L	T	P	C		
L9 Semester IV	MTS–SEC- 423	Number Theory	3	1	0	4	IA(Mid) – 40 EA(End Sem) – 60	Dr. R.K. Pandey

Lectures Hrs. 60

Learning Objectives:

1. To explain the fundamentals of algebraic number theory.
2. To explain congruence relations.
3. To introduce various arithmetic functions and their applications.
4. To explain the solution approach of Diophantine equations.
5. To explain the concept of generating functions.

Course Learning Outcomes: After completion of this course students will be able to:

CO1: Interpret the divisibility of numbers.
CO2: Learn congruences and its basic properties.
CO3: Understand to solve congruence equation.
CO4: Learn the notion of arithmetic functions.
CO5: Learn some famous theorems.

Unit wise Learning Outcomes

UO1: Learning about better intuition to check the divisibility of numbers.
UO2: Learning about skills to solve congruence equations.
UO3: Understanding about the applications of congruences.
UO4: Learning about the skills of deriving and obtaining quadratic residues.
UO5: Awareness about the way to solve Diophantine equations.

Unit-I: Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem.
Unit-II: Euler's phi-function, Divisor function, Mobius function mu(n), some properties of the arithmetic function. Congruence modulo powers of prime; primitive roots and their existence; quadratic residues.
Unit-III: Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol. Solutions of Diophantine Equations.
Unit-IV: Solutions of $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$; properties of Pythagorean triples; sums of two, four and five squares; assorted examples of diophantine equations; Generating function models; Generating functions and recurrence relations.
Unit-V: Calculating coefficient of generating functions, Partitions, Exponential generating Functions, summation method. Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of linear, recurrence relations, Solution of inhomogeneous recurrence relations, Solutions with generating functions.

Essential Readings:

1. Niven, I., Zuckerman, H. S. and Montgomery, H. L. (2003) An Introduction to the Theory of Numbers (6th edition) John Wiley and Sons, Inc., New York.
2. Burton, D. M. (2002) Elementary Number Theory (4th edition), Universal Book Stall, New Delhi.

Suggested Readings:

1. Hardy, G.H. and Wright, E. M.(1998) An Introduction to the Theory of Numbers (6th edition), The English Language Society and Oxford University Press.
2. J. H. Silverman, (2019): A friendly introduction to number theory, Fourth Edition, Pearson.

E-Resource :

1. https://archive.nptel.ac.in/courses/111/101/111101137/
2. https://ocw.mit.edu/courses/18-785-number-theory-i-fall-2021/
3. National Digital Library

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Passed by Board of Studies Dated 11/06/24

School Board Meeting held on 14th June, 2024

The School Board has approved the minute of meeting of BOS of Department of Mathematics and Statistics held on 11/06/2024.

Prof. A.K. Saxena
External Member
Department of Mathematics, Maharaja Chhatrasal University, Chhatarpur (M.P.)

Prof. K.S. Varsney
External Member
HoD Physics, D.S. College, Aligarh, U.P.

Prof. Narendra Pandey
External Member
Department of Physics,
University of Lucknow (U.P.)

Prof. Diwakar Shukla
Member
HoD, Department of Mathematics & Statistics
Dr. Harisingh Gour V.V., Sagar (M.P.)

Prof. Ashish Verma
Member
HoD, Department of Physics
Dr. Harisingh Gour V.V., Sagar (M.P.)

Prof. R.K. Rawat
Member
Department of Applied Geology,
Dr. Harisingh Gour V.V., Sagar (M.P.)

Prof. Ranveer Kumar
Member
Department of Physics
Dr. Harisingh Gour V.V., Sagar (M.P.)

Prof. U.K. Patil
Member
Department of Pharmaceutical Science,
Dr. Harisingh Gour V.V., Sagar (M.P.)

Dr. Abhishek Bansal
Member & Associate Professor
HoD, Department of Computer Science & Applications
Dr. Harisingh Gour V.V., Sagar (M.P.)

Prof. U.K. Khedlekar
Member & Associate Professor
Department of Mathematics & Statistics,
Dr. Harisingh Gour V.V., Sagar (M.P.)

Dr. Rekha Garg Sonaki
Member & Associate Professor
Department of Physics
Dr. Harisingh Gour V.V., Sagar (M.P.)

Prof. Kamal Kant Ahirwar
Member & Assistant Professor
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Dr. Mahesh Kumar Yadav
Member & Assistant Professor
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Dr. Maheshwar Panda
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Dr. Harisingh Gour V.V., Sagar (M.P.)

Ms. Shivani Khare
Member & Assistant Professor
Department of Vedic Studies
Dr. Harisingh Gour V.V., Sagar (M.P.)

Prof. R.K. Tangele
Chairman, School Board & Dean, SMPS
Dr. Harisingh Gour V.V., Sagar (M.P.)