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 -16/09/2022

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

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 for Post Graduate Diploma

1. **Name of the Programme : Post Graduate Diploma**
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.

5. Structure of the Programme for Post Graduate Diploma

L-5

	Semester I				
Level 8	**Nature of Course**	**Course Code**	**Course Title**	**Credits**	**Course Coordinator**
	Discipline Specific Major-1	MTS-DSM-121	Abstract Algebra	4	Dr. M.K.Yadav Dr. K.Shrivastava
	Discipline Specific Major-2	MTS-DSM-122	Real Analysis-II	4	Dr. RK Pandey
	Discipline Specific Major-3	MTS-DSM-123	Topology	4	Dr. P. Gupta
	Multi-Disciplinary Major-1	MTS-MDM-121	Operation Research-I	4	Dr. U.K.Khedlekar
	Skill Enhancement Course (SEC)	MTS-SEC-121	Integral Transform	4	Dr. Bhupendra
	Semester II				
	Nature of Course	**Course Code**	**Course Title**	**Credits**	**Course Coordinator**
	Discipline Specific Major-1	MTS-DSM-221	Complex Analysis	4	Dr. S. Kumar
	Discipline Specific Major-2	MTS-DSM-222	Measure Theory	4	Dr. T Nath
	Discipline Specific Major-3	MTS-DSM-223	Partial Differential Equations	4	Dr. M.K.Yadav
	Multi-Disciplinary Major-1	MTS-MDM-221	Mathematical Modeling in Biology	4	Dr. K.S.Mathur
	Skill Enhancement Course (SEC)	MTS-SEC-221	Project	4	Research Areas of Faculty Members

6. Exit: Certificate in Mathematical Sciences

7. 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

8. 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

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

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

60 hours

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 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

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

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

Lectures/Hrs.:60

Learning Objectives

To explain fundamentals of Riemann-Stieltjes integration and its uses.
To introduce the Rearrangement of series, Riemann's rearrangement theorem.
To explain sequence and series sequence of functions, uniform convergence.
To explain the derivation Inverse function and its applications.
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-Sintegral, 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.

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

Level & Semester	Course Code	Title of the Course	Credits				Marks	Course Coordinator
			L	T	P	C		
L8 Sem I	MTS-DSM-123	Topology	4	0	0	4	IA(Mid)-40 EA(End Exam)-60	Dr. Punam Gupta

Lectures/Hrs: 60

Learning Objectives: This course will enable the students to:
To introduce point set topology or general topology.
To explain the topological properties of topological spaces.
To study product spaces and quotient spaces.
To teach Urysohn lemma & Tietze Extension Theorem.
To explain the characteristics of topological space.

Course Learning Outcomes:

CO 1 After completion of this course, students will know the definitions of standard terms in topology.

CO 2 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.

CO 3 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-I - Course (nptel.ac.in)

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

Level & Semester	Course Code	Title of the paper	Credits				Marks	Course Coordinator
			L	T	P	C		
L8 Sem-I	**MTS-MDM-121**	**Operations Research-I**	**4**	**0**	**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: This is 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: To study the Scope of Operations research and its necessity in real life.
UO 2: To study the method of problem solving using Simplex Method.
UO 3: To study the control and management of inventory system.
UO 4: To solving the transportation and assignment problem.
UO 5: To study of 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=BDBhpxRzImI&list=PLWoXNEI-KK1mCv_EL4OdF_-FXryaZ11N
2. www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf

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

Level & Semester	Course Code	Title of the Course	Credits				Marks	Course Coordinator
			L	T	P	C		
L8 Sem I	MTS-SEC-121	Integral Transform	4	0	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: To learn about Fourier series.
UO2: To learn about Fourier transform and its properties and will be able to solve the examples based on it.
UO3: To learn about Laplace Transformation and its real life application.
UO4: To learn about Inverse Laplace Transform.
UO5: To 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=c2b5RnIo95I
4. https://www.youtube.com/watch?v=00ZNhBQ1vaQ

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

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

Lecture/Hrs. 60

Learning Objectives:

a. Importance of analytic functions in the complex integration.
b. Applications of identity theorem in Maximum modulus principle.
c. Classification of singularities and learn to use Argument principle.
d. Evaluation of real integrals using complex line integration
e. 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/L9ZmpWxG9HiRaLDQpQJHWBn1kZYf7BhnE4Y5N6ObgLADhA2QYtQM8a1eRBoOZAqzik_FHKiB4c_L4Zmy7PQsdA

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

Level & Semester	Course Code	Title of the Course	Credits				Marks	Course Coordinator
			L	**T**	**P**	**C**		
L8 Sem II	**MTS – DSM - 222**	**Measure Theory**	4	0	0	4	**IA (Mid) - 40 EA (End Sem) - 60**	**Dr. T. Nath**

Lecture/Hrs. 60

Learning Objectives:
- To inculcate the basic features of Lebesgue measures.
- To acquainted with Lebesgue Integration.
- To introduce theL^p --space and some inequalities.
- 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 aboutconvex 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,$\sigma-$ 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/**

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

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

Lecture/Hrs. 60

Learning Objectives:

- To develop students' skills in the theory and applications oflinear and nonlinear partial differential equations and to provide rigorous instruction to the fundamental concepts and skills.
- To introduce students the diversity where the partial differential equations be applied and utilised.

To provide an advanced treatment of methods forsolution 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 solvingskills 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

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 Coordinator
			L	T	P	C		
L8 Sem II	**MTS-MDM-221**	**Mathematical Modeling in Biology**	**4**	**0**	**0**	**4**	**IA (Mid) -40 EA (End Sem) - 60**	**Dr. K.S.Mathur**

Lecture/Hrs. 60

Learning Objectives:

- To develop students' skills in mathematical modeling through linear and nonlinear differential equations and 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 problems in ecology and epidemiology; to give mathematics and biological students the opportunity to gain familiarity with the applications of mathematics in biology.
- To provide an introduction to the modelling and analysis of solutions of problems in ecology and epidemiology, particularly those that can be addressed via dynamical systemstechniques.

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), Impulsive differential 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