General Scheme

Sant Gadge Baba Amravati University Amravati

Scheme of Teaching, Learning & Examination leading to the Degree

Master of Science (Mathematics)-2023-24

(Two Years ... Four Semesters Degree Course- C.B.C.S) (M. Sc. Part-II) Semester- III

S. N.	Subject	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme						
			Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing	
											Theory		Practical		Total Marks		
			L	T	P	Total	L/ T	Practical	Total		Theory+ MCQ External	Theory Internal	Internal	External		Marks	Grade
1	DSC I Functional Analysis-I		4	-	-	4	4	-	4	3	80	20			100	40	P
2	DSC II Advanced Mechanics		6	-	-	6	6	-	6	3	80	20			100	40	P
3	DSC-III Operational Research		6	-	-	6	6	-	6	3	80	20			100	40	P
4	DSE IV/V General Relativity (Optional)		6	-	-	6	6	-	6	3	80	20			100	40	P
5	DSE IV/V Difference Equation – I (Optional)		6			6	6		6	3	80	20			100	40	P
7	DSE IV/V Fluid Dynamics–I (Optional)																
8	DSE IV/V Advanced Complex Analysis –I (Optional)																
9	DSE IV/V Banach Algebras-I (Optional)																
8	**SEC (Skill Enhancement Course)** **1. Vedic Mathematics** **OR** **2. Arc Radius Goba Verification and its Applications**		2			2			2		40	10			50	20	P
	TOTAL					30			30						550		

General Scheme

Sant Gadge Baba Amravati University Amravati

Scheme of Teaching, Learning & Examination leading to the Degree

Master of Science (Mathematics)- 2023-24

(Two Years ... Four Semesters Degree Course- C.B.C.S) (M. Sc. Part-II) Semester- IV

S. N.	Subject	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme						
			Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing	
											Theory		Practical		Total Marks		
			L	T	P	Total	L/ T	Practical	Total		Theory+ MCQ External	Theory Internal	Internal	External		Marks	Grade
1	DSC-I Functional Analysis-II		6	-	-	6	6	-	6	3	80	20			100	40	P
2	DSC-II Partial Differential Equations		6	-	-	6	6	-	6	3	80	20			100	40	P
3	DSC-III Numerical Analysis		6	-	-	6	6	-	6	3	80	20			100	40	P
4	DSE-IV/V Relativistic Cosmology (Optional)		6	-	-	6	6	-	6	3	80	20			100	40	P
5	DSE-IV/V Fluid Dynamics–II (Optional)		6			6	6		6	3	80	20			100	40	P
7	DSE-IV/V Difference Equation –II (Optional)																
8	DSE-IV/V Lie Groups (Optional)																
9	DSE-IV/V Banach Algebras-II (Optional)																
8	Research/Innovative Project/ Dissertation								5		50	50			100	50	P
	TOTAL					30			35						600		

SANT GADGE BABA AMRAVATI UNIVERSITY, AMRAVATI

Faculty: Science and Technology
Programme: M.Sc. Mathematics

PO's

At the end of the programme, students would be able to

PO-1: Apply knowledge of Mathematics, in all the fields of learning including higher research and its extensions.
PO-2: Innovate, invent and solve complex mathematical problems using critical understanding, analysis and synthesis.

PO-3: Adjust themselves completely to the demands of the growing field of Mathematics by lifelong learning.
PO-4: Effectively communicate about their field of expertise on their activities, with their peers and society at large, such as, being able to comprehend and write effective reports and design documentation, and make effective presentations.
PO-5: Crack lectureship and fellowship exams approved by UGC like CSIR – NET and SET.

PSOs

Upon completion of the programme successfully, students would be able to
PSO-1: Develop problem-solving skills and apply them independently to problems in pure and applied mathematics.
PSO-2: Understand advanced mathematical knowledge and skills that prepare them to pursue further studies and research.
PSO-3: Understand advanced and pure mathematical concepts and research.
PSO-4: Create knowledge, capability in formulating and analyzing mathematical models of real-life applications.
PSO-5: Analyze the latest advances in applied mathematics such as numerical computations and mathematical modelling in physical sciences.

Employability Potential of the Programme:

After completing M.Sc. in Mathematics, my career will be more stable and successful. The private and government sectors both have thousands of job options available. The government sector also wants a good mathematician, who can manage the data and business model. Every business requires financial activity and data management for better improvement and success. Various companies have positions like numerical operations and accounting. So, career after **M.Sc. Mathematics** is very fruitful.

The job profile option after completing the M.Sc. Mathematics as follows:

1. **Assistant Professor in Mathematics.**
Many of the colleges and Universities/Institutes can offer jobs as Assistant Professors after clearing SLET/ CSIR-NET examination or Ph.D. degree.

2. **Junior Research Fellow**
The Junior research fellow exam is now conducted by NTA. Normally only top candidates acquire the JRF post after clearing the NET/GATE exam.

3. **Scientific Officer**

Students can apply for a scientific office job in the industry such as **ISRO** (the Indian Space research Organization), **DRDO** (Defense Research and Development Organization), TIFR (Tata Institute of Fundamental Research) and **NAL** (National Aeronautics Limited).

4. **Operational Research.**

Students can also become operational researchers if they are good at mathematics. Under this profession basically, they have to solve the business profitability, improve efficiency, and complex organization problems. Also have to understand the assigned assignment in depth. And they have to use **mathematical programming, analyst techniques, optimizatio**n, and so on for enhancing the project planning and skills.

5. **Statistical Research.**

A career in statistical research is very interesting. It presents the company's statistical businesses at a modest and technical level. Under this profession, students will get the chance to analyze, research, use mathematical tools, algorithms, and theories, and become a professor.

6. **ICT**

Information and communication technology is playing a big role in this platform. ICT always offers a new role for Mathematics Post graduate students. Such as the development of ICT, Regular Maintenance, Manufacturing and design part, general part, and so on.

7. **Data Science Modelers.**

The demand for data science specialists is huge because every company wants to convert its data into the required information. Making a good information sheet helps company decision-maker to make the best decision for the company.

8. **Banking – Investment Banking.**

Many famous investment banks provide financial advice to the customer. These professions help to increase the equity and debt market. A career in investment banking is a very high-profile post along with good stability. In this profession, students have to deal with the clients and the market. Some basic skills required for an investment banker. Integrity, knowledge of finance and the markets, interpersonal skills, communication, etc. **Job opportunities** come from various areas such as finance, Wells Fargo, American Express, Deutsche bank, CICNA, Barclay's bank, AIG, JP Morgan, Goldman Sachs, etc.

Syllabus Prescribed for the Year 2023-24 PG- CBCS Programme

M.Sc. PART -II (MATHEMATICS) SEMESTER-III and IV

M.Sc. Part-II Semester-III: Compulsory Papers

DSC-I Functional Analysis-I
DSC-II Advanced Mechanics
DSC-III Operations Research

Optional Papers: Choose Any Two from the following.

DSE-IV/V Fluid Dynamics-I
General Relativity
Difference Equations-I
Advanced Complex Analysis
Banach Algebras -I

M.Sc. Part-II Semester-IV: Compulsory Papers

DSC-I Functional Analysis-II
DSC-II Partial Differential Equations
DSC-III Numerical Analysis

Optional Papers: Choose Any Two from the following.

DSE-IV/V Fluid Dynamics-II
Relativistic Cosmology
Difference Equations-II
Lie Groups
Banach Algebras-II

Programme: M.Sc.-II (Semester-III), Mathematics

Syllabus Prescribed for the year 2023-24, PG Programme

Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-I / Mathematics	**Functional Analysis-I**	04

COs: On successful completion of this course, students would be able to

- Discuss normed spaces, subspaces, continuity, Banach spaces and Hilbert spaces.
- Analyze eight equivalent conditions of continuity on normed spaces and Banach spaces.
- Sketch the proof of uniform boundedness principle, closed graph theorem, open mapping theorem, Hahn Banach theorem and its extension.
- Classify operators on Banach spaces.
- Evaluate linear equations in Banach spaces.

- Differentiate different types of linear spaces.

Unit	Content
Unit I	Normal linear spaces, Banach spaces and examples. Quotient spaces of normed linear spaces and its completeness, equivalent norms, Riesz lemma. **(11 Hrs.)**
Unit II	Basic Properties of Basic Properties of finite dimensional normed linear spaces and compactness. Weak convergence and bounded linear transformations, normed linear spaces of bounded linear transformations, Dual spaces with example. **(10 Hrs)**
Unit III	Boundedness theorem and some of its consequences, Open mapping, Hahn Banach theorem for real linear spaces, complex linear spaces and normed linear spaces. **(11 Hrs.)**
Unit IV	Reflexive Spaces, Weak sequential compactness, compact operators, solvability of linear equations in Banach spaces, the closed graph theorem. **(11 Hrs.)**
Unit V	Inner product spaces, Hilbert spaces, orthogonal sets, Bessel's Inequality, complete orthogonal sets, Parseval's identity, structure of Hilbert spaces. **(11 Hrs.)**

Text Book:

1) E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, New York, 1978.

Reference Books:

1) Serge Lang, Analysis I&II, Addison-Wesley Publishing Company, Inc.1967.
2) G. Bachman and L. Narici, Functional Analysis, Academic Press,1966.
3) N. Dunford and J.T. Schwartz, Linear Operators, Part-I, Inter science, New York, 1958.
4) R.E. Edwards, Functional Analysis, Holt Rinehart and Winston, New York,
5) C. Goffman and Pedrick, First Course in Functional Analysis, Prentice Hall of India, New Delhi
6) P. K. Jain, O. P. Ahuja and Khalil Ahmad, Functional Analysis, New Age International (P) Ltd. & Wiley Eastern Ltd., New Delhi,1997.
7) R. B. Holmes, Geometric Functional Analysis and its Applications, Springer-Verlag, 1975.
8) K.K. Jha, Functional Analysis, Students Friends, 1986.

Programme: M.Sc.-II (Semester-III), Mathematics
Syllabus Prescribed for the year 2023-24, PG Programme
Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-II / Mathematics	Advanced Mechanics	06

COs: On successful completion of this course, students would be able to

- Apply the Variational principles to real physical problems
- Develop mechanical systems, both in inertial and rotating frames, using Lagrange and Hamilton equations

- Describe the motion of a mechanical system using Hamilton-Jacobi equation.
- Convince the mechanism of canonical transformation.

Unit	Content
Unit I	Legendre's transformation and Hamilton equation of motion, cyclic coordinate and conservation theorem, the Hamiltonian formulation of relativistic mechanics, the equation and example of canonical transformation **(14 Hrs.)**
Unit II	Poison brackets and other canonical equivalent equation of motion, infinite decimal canonical transformation and cartesian theorem in poison bracket formulation, angular momentum, Poisson bracket relation, symmetric group of mechanics system, Liouville's theorem **(14 Hrs.)**
Unit III	The Hamilton-Jacobi equation for Hamilton principle, the harmonic oscillator, problem as an example of the Hamilton-Jacobi method, the Hamilton-Jacobi equation for Hamilton-Jacobi characteristic function, separation of variable in the Hamilton-Jacobi equation, ignorable coordinate and Kepler problem, action angle variable in system of one degree of freedom, action angle variable for completely separable system, the Kepler's problem in action variable. **(15 Hrs.)**
Unit IV	Cayley Klein parameter and related quantities, rate of change of vector, the Cayley's effect, the angular momentum, kinetic energy of motion about a point, the inertia tensor and moment of inertia solving rigid body problem, Euler's equation of motion, torque of rigid body, the heavy symmetrical torque with one point fixed. **(15 Hrs.)**
Unit V	The time dependent perturbation theorem, illustration the dependents perturbation theory, time independent perturbation theory **(14 Hrs.)**

Text Book:

1) Goldstein H, Classical Mechanics, Narosa Publishing House, (Second edition)

Reference Books:

1) Goldstein Pooler & Saflco, Classical Mechanics, Pearson Educations.

2) N.C. Rana & P. S. Jog, Classical Mechanics, Tata Mc. Graw Hill (1992).

3) A. S. Ramsey Dynamics Part-II, the English Language Book Society and Cambridge University Press.

4) Gupta, Kumar and Sharma, Classical Mechanics

5) T.M. Karade, G. S. Khadekar, Lectures on Advanced Mechanics, Sonu-Nilu publication

6) I.D. Landau and E.M. Lifchitz, Vol. I third edition, Perguman press, New Delhi

7) L.M. Katkar, Classical Mechanics (Mathematics), Shivaji University Kolhapur, 2007

Programme: M.Sc.-II (Semester-III), Mathematics

Syllabus Prescribed for the year 2023-24, PG Programme

Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-III / Mathematics	Operations Research	06

COs: On successful completion of this course, students would be able to

- Describe mathematical tools needed to evaluate optimization problems.
- Develop a report that describes the model and the solving technique.
- Recognize the properties of the queuing system.
- Analyze the results and propose recommendations in language understandable to the decision-making processes
- Formulate Linear Programming problems.

- Apply methods to solve LPP.
- Compute Game Theory Problems.
- Use Queuing Theory for Stochastic Process and Markov Chain.

Unit	Content
Unit I	Operation Research & its scope, linear programming, Mathematical formulation, Graphical Solution, General Linear Programming (LP), Simplex method, Use of Artificial variable (Big M method), Duality in LP., Economic Interpretation, dual simplex method. **(15 Hrs.)**
Unit II	Integer Programming, Branch and Bound Technique, Fractional Cut plane method, Goal programming, Advanced techniques in LP (upper bound technique) **(14 Hrs.)**
Unit III	Parametric linear programming, Transportation problem and assignment problems. **(14 Hrs.)**
Unit IV	Queuing system, basic properties of queuing system, Element of Queuing system, Poisson and Non-Poisson Queuing system **(15 Hrs.)**
Unit V	Game and strategies, two person zero sum games, the maximum-minimum principle, game without saddle point, mixed strategies, graphics solution of 2 x n and m x 2 games, dominance properties, general solution of m x n rectangular games **(14 Hrs.)**

Text Book:

1) Kanti Swaroop, P. K. Gupta and Manmohan, Operations Research, Sultan Chand &Sons, New Delhi 2007.

Reference Books:

1) G. Hadley, Nonlinear and Dynamic Programming, Addison-Wesley. Reading Mass.
2) Mokhtar S. Bazaraa, Hohn J. Jarvis and Hanif D. Sherali, G. Hadley, Linear Programming and Network flows,
3) John Wiley and Sons. NewYork,1990.
4) H. A. Taha, Operation Research-an Introduction, Macmillan Publishing Company, Inc, New York.
5) S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
6) Prem Kumar Gupta and D.S. Hira, Operation Research-an Introduction, Chand & Company Ltd., New Delhi.
7) N.S. Kambo, Mathematical programming Techniques. Affiliated East-West Press Pvt. Ltd., New Delhi, Madras.
8) F.S. Hillier and G.J. Lieberman, Introduction to Operations Research (6thEd.) McGraw Hill International Edition, Industrial Engineering Series,1995.
9) Kanti Swaroop, P. K. Gupta and Manmohan, Operations Research, Sultan Chand &Sons, NewDelhi-2007.

Programme: M.Sc.-II (Semester-III), Mathematics
Syllabus Prescribed for the year 2023-24, PG Programme
Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-IV / Mathematics	**General Relativity (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Represent Lorentz group, Time dilation, Space contraction.
- Recognize contraction symmetric and skew symmetric tensors.
- Express tensor algebra and calculus in curved space-time.
- Deduce Einstein field equations for different spacetimes.
- Analyse gravitational waves, weak gravitational waves, gravitational waves in curved space time.
- Differentiate between Schwarzschild interior and exterior solutions.

Unit	Content
Unit I	Einstein's relativity: SR to GR, Principle of equivalence, Principle of covariance and Mach's Principles, Einstein's field equations, Derivation of Einstein's field equations from action principle, Newtonian approximation: Relation between g_{44} and V, Einstein equations compared with Poisson equation. (**14 Hrs.)**
Unit II	Schwarzschild exterior solution and its isotropic form, Birkhoff's Theorem, planetary orbits, General relativistic Kepler problem, Advance of Perihelion of a planet, Bending of light ray in a gravitational field, gravitational red shift in spectral lines **(15 Hrs.)**
Unit III	Schwarzschild interior solutions, field of charged mass point the boundary conditions, covariant conservation law, the tetroid representation of Einstein equations, Eddington's Form of Form of Schwarzschild Solution **(15 Hrs.)**
Unit IV	Gravitational Collapse of Spherical Body, blackhole, gravitational collapse of a dust like sphere, Kerr metric, gravitational collapse of a non-spherical and rotating body **(14 Hrs.)**
Unit V	Gravitational waves, weak gravitational waves, gravitational waves in curved space time, strong gravitational waves, radiation of gravitational waves **(14 Hrs.)**

Text Book:

1) Elements of General Relativity and Cosmology: T. M. Karade, Sonu Nilu Publication, Einstein Foundation International, Nagpur, 2023.

References Books:

1) Introduction to General Relativity - Ronald Adler, Maurice Bazin, Menahem, Schiffer, 2nd Edition, Mc Graw Hill Company.
2) Mathematical Theory of Relativity: A.S. Eddington, CambridgeUniversityPress,1965.
3) Relativity: The General Theory - J.L. Synge, North. Holland Publishing Company, 1976.
4) The Classical Theory of Fields -L.D. Landau and E. M. Lifshitz, Pergamon Press,1980.
5) An Introduction to Riemannian Geometry and the Tensor Calculus
6) C. E. Weatherburn, Cambridge UniversityPress,1950.
7) Classical Theory of Fields by L. D. Landau and E. M. Lifshitz.

Programme: M.Sc.-II (Semester-III), Mathematics
Syllabus Prescribed for the year 2023-24, PG Programme
Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V / Mathematics	**Fluid Dynamics-I (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Equipped with essential concepts of Fluid Mechanics introducing them to research in applied mathematics.
- Discuss the case of steady motion under conservative body forces, some potential theorem
- Recognize the use of the equation of state of substance, the first law of Thermodynamics, internal energy of a gas.
- Analyze the Milne-Thomson circle theorem, some of its application of the circle theorem,

Unit	Content
Unit I	Kinematics of fluid in Motion: Real fluids and ideal fluids. Velocity of fluid at a point stream lines and path lines. Steady and unsteady flows. Velocity Potential, vorticity vector, local and particle rates of change. Equation of continuity, worked examples. Acceleration of a fluid. Conditions at a Rigid Boundary, general analysis of fluid motion. **(15 Hrs.)**
Unit II	Pressure of motion of a fluid: Pressure at a point in a fluid at rest. Pressure at a point in moving fluid, conditions a boundary of two inviscid immiscible fluids, Euler's Equation of Motion. Bernoulli's Equation, worked examples. Discussion of the case of steady motion under conservative body forces, some potential theorem, some special two-dimensional flow. Some Further Aspects of Vortex Motion. **(14 Hrs.)**
Unit III	Sources, sinks and Doublets, images in a rigid infinite plane. Images in Solid Spheres. Ascii-symmetric flow, Stokes Stream Function. Some Two-dimensional flows, meaning of two-dimensional flow, use of cylindrical polar coordinate, the stream function, the complex potential for two dimensional, irrotational incompressible flow. Complex Velocity Potential For standard two-dimensional flows, uniform stream, line source and link sinks, link system. **(14 Hrs.)**
Unit IV	The Milne-Thomson circle theorem, some application of the circle theorem, extension of the circle theorem, the theorem of W a sins, the use of conformal transformation. Vortex Rows, single infinite row online vortices. The Karnar vortex street. **(14 Hrs.)**
Unit V	Elements of Thermodynamics: The equation of state of substance, the first law of Thermodynamics, internal energy of a gas. Specific heat of a gas. Function of state, Entropy, Maxwell's Thermodynamics relation. Isothermal Adiabatic and Isentropic Process. **(15 Hrs.)**

Text Book:

1) F. Chorlton, Text Book of Fluid Dynamics, CBS Publishers, Delhi

References Books:

1) Besaint and A.S. Ramsay, A Treatise on Hydrodynamics, Part-II, CBS Publishers, Delhi,1988
2) G.K. Batchelor, Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.
3) H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York,1971.
4) M.D. Raisinghania, Fluid Mechanics (With Hydrodynamics), S. Chand and Company Ltd., New Delhi.
5) L.D. Landen and E.M. Lipschitz, Fluid Mechanics, Pergam on Press, London,1985.
6) R. K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi,1976.

7) A.D. Young, Boundary Layers, AIAA Education Series, Washington, DC,1989.
8) S.W. Yuan, Foundation of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi,1976.

Programme: M.Sc.-II (Semester-III), Mathematics

Syllabus Prescribed for the year 2023-24, PG Programme
Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V/ Mathematics	**Difference Equation-I (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Solve linear and nonlinear difference equations by various methods.
- Discuss the initial value problems for linear systems, identify the stability of linear systems, to learn the phase plane analysis for linear systems and stability of nonlinear systems.
- Apply the theory of difference equations in different engineering problems. Also, to make discrete mathematical models.
- Judge the difference between the qualitative and quantitative behaviour of solutions of the difference equations and the corresponding differential equations.
- Analyze the properties of Z-transform.

Unit	Content
Unit I	Introduction: Difference Calculus. The Difference Operator. Generating Function and approximate summation. **(15 hrs.)**
Unit II	Linear Difference Equations: First Order Equations, General Results for Linear Equations. Equations With Constant Coefficients. Applications, Equations with Variable Coefficients. Nonlinear equations that can be linearized. **(15 hrs.)**
Unit III	The Z-transform: Properties, initial and final value theorems, partial sum theorem, convolution theorem. Inverse Z-transforms solution of difference equation with constant coefficients by Z-transforms. **(14 hrs.)**
Unit IV	Stability Theory: Initial value problems for linear systems. Stability of linear systems. Stability of nonlinear system. Chaotic behaviour. **(14 hrs.)**
Unit V	Asymptotic Methods: Introduction, Asymptotic analysis of sums, linear equations, non-linear equations. **(14 hrs.)**

Text Book:

1) Walter G. Kelley and Allan C. Peterson, Difference Equations: An Introduction with Applications, Academic Press, Inc. Harcourt Brace Jovanovich Publishers,1991.

References Books:

1) Eugenio Hernandez & Guido Weiss, A First Course on Wavelets, CRC Press, New York
2) Chui C.K., An Introduction to Wavelets, Academic Press,1992.
3) M.W. Wang: Wavelet Transforms & Localization Operators, Birkhauser B Verleg.
4) Gerald Kaiser: Friendly Guide to Wavelets, Birkhauser,1994.

Programme: M.Sc.-II (Semester-III), Mathematics
Syllabus Prescribed for the year 2023-24, PG Programme
Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V / Mathematics	**Advanced Complex Analysis-I (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Discuss the Gamma Function and its properties.
- Apply the monodrama theorem and Its consequences properly.
- Express an analytic function in terms of power series in the domain of analyticity.
- Recognize the characteristics of a complex function in the neighbourhood.
- Acquire the skill of contour integration to evaluate complicated real integrals via residue calculus.
- Differentiate the characteristics of analytic functions.
- Analyze conformal mapping to compute geometric mappings.
- Extend analyticity continuation to analytic function and its natural boundary.
- Discuss convergence of a sequence of complex functions.

Unit	**Contents**
Unit-I	Montel's Theorem, Spaces of Meromorphic functions, The Riemann Mapping Theorem, The Weierstrass factorization Theorem, Factorization of Sine function **(14 Hrs.)**
Unit-II	The Gamma Function and its properties, The Riemann Zeta Function, Riemann's Functional Equation, Euler 's Theorem, Mittage- Leffler's Theorem. **(14 Hrs.)**
Unit-III	Monodromy theorem and its consequences, The Sheaf of Germs of Analytic function on an open set, Harmonic function on a disc, Harnack's inequality, Dirichlet's Problem, Green's Function. **(14 Hrs.)**
Unit-IV	Canonical Products, Jensen's Formula, Poisson-Jensen Formula, The genus and order of an entire function, exponent of convergence, Hadamard's factorization Theorem. **(15 Hrs.)**
Unit-V	The range of an Analytic function, Bloch theorem, Little Picard's theorem, Schottky's theorem, univalent function, Bieberbach's conjecture theorem, Cobe's "1/4". **(15 Hrs.)**

Text Book:

1) Walter Rudin, Real and Complex Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2) S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House,1967.

References Books:

1) H. S. Kasana, Complex Variables: Theory and Application, PHI Learning Pvt. Ltd., New Delhi.
2) Schaum's outline series Complex Analysis, Tata McGraw Hill Education Pvt. Ltd., New Delhi (2010).
3) J. N. Sharma, Complex Variables, Pragati Publication
4) A. R. Vasishtha, Complex Variables, Krishna Publication.
5) Murray R. Spiegel, Seymour Lipschutz, Jon J. Schiller, Dennis Spellman. Schaum's outline series Complex Analysis, TataMcGrawHillEducationPvt.Ltd.,3rdEdition, New Delhi2010.
6) J. Ward Brown, Ruel V. Churchill, Complex variables Application, Mc Graw Hill International Edition (2009).
7) H. A. Priestley, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.

8) Liang-Shin Hahn & Bernhard Epstein, Classical Complex Analysis, Jones&BerlettPublishers.InternationalLondon,1996. 9) L. V. Ahlfors, Complex Analysis, McGraw Hill,1979.
10) S. Lang, Complex Analysis, Addison Wesley,1977.1998.
11) D. Sarason, Complex Function Theory, Hindustan Book, Agency, Delhi,1994.
12) Mark J. Ablowitz and A. S. Fokas, Complex Variables: Introduction Application, Cambridge University Press,South Asian Edition,56.
13) E. Hille, Analytic Function Theory (2 Vols), Gonn & Co.1959.
14) W.H.J. Fuchs, Topicsinthe Theory of Function of Complex Variable,
15) D. Van NostrandCo.,1967. C. Carathedory, Theory of Functions (2 Vols), Chelsea PublishingCompany,1964.
16) M.Heins, Complex Function Theory, Academic Press,1968
17) S. Saks A. Zygmund, Analytic Functions, Monografie, Matematyczne,1952.
18) Titchmarsh, the Theory of Functions, Oxford University Press, London.
19) W.A. Veech, A Second Coursein Complex Analysis, W.A. Benjamin,1967.
20) Complex variables and Applications, Jams Ward Brown, Ruel V. Churchill, McGraw Hill International Edition (2009).
21) Dennis G. Zill, Patrick S. Shanhan Jones and Bartlett, A First Course In Complex Analysis with Application (Second edition) Publisher (2010).
22) John Mathewand Howell, Complex Analysis for Mathematicians and Engineers.
23) Functions of one complex variable - J. B. Conway, Springer Verlag International Students Edition, Narosa Publishing House,1980.

Programme: M.Sc.-II (Semester-III), Mathematics Syllabus
Prescribed for the year 2023-24, PG Programme
Programme: M.Sc.-II (Mathematics)

Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V / Mathematics	**Banach Algebras-I (Optional)**	06

COs: On successful completion of this course, students would be able to

- Understand the concept of normed linear spaces, Banach spaces and Hilbert spaces.
- Compute the dual spaces of certain Banach spaces and Hilbert space.
- Evaluate the orthonormal vectors and spectral properties of bounded Linear operators.
- Obtain self-adjoint and normal operators.
- Recognize properties of compact linear operators.

Unit	**Content**
Unit I	Definition of Banach Algebra and Examples. Singular and non-singular elements. The abstract index. The spectrum of an element **(15 Hrs.)**
Unit II	Spectral radius, Gelfand formula. Multiplicative linear functionals and the maximal ideal space. Gleason Kahane Zelazko theorem **(14 Hrs.)**
Unit III	The Gelfand Transforms the spectral mapping theorem. Isometric Gelfand transform. Maximal ideal spaces for disc algebra and algebra 1(Z). **(15 Hrs.)**
Unit IV	C*-algebras: Definition and Examples, self-adjoint, unitary, normal, positive and projection elements in C*-algebras. **(14 Hrs.)**
Unit V	Commutative C*algebras. C*-homomorphisms. Representation of commutative C*-algebras. **(14 Hrs.)**

Text Book:

1) T. W. Palmer, Banach Algebras Vol.-I, Cambridge University Press,1994

References Books:

1) M. A. Naimark, Normed Algebras, Groningen, Netherlands,1972
2) C. E. Rickart, General Theory of Banach Algebras, Von Nostrand,1960.

Programme: M.Sc.-II (Semester-III), Mathematics
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Semester- III		
Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods/week)
SEC (Skill Enhancement Course)	Vedic Mathematics (Optional)	02

Cos: - On successful completion of this course, students would be able to

- **Understand the essentiality of Vedic Mathematics.**
- **Overcome the fear of mathematics.**
- **Appreciate the mathematical advancement of ancient India.**
- **Understand the contribution of ancient Indian mathematicians.**

Unit	Content
Unit I	General equations, simultaneous linear equations, square root of imperfect squares, cubic numbers, base method of division. **(08 hrs.)**
Unit II	Contribution of ancient Indian mathematicians in arithmetic contribution of ancient Indian mathematicians in algebra and geometry (Brahmagupta, Shrinivasa Ramanujan, Aryabhata (5^{th} Century), D.R. Kaprekar, Nilkantha Somayaji, Bhaskaracharya (12^{th} Century), Study of Janorkar's research etc. **(08 hrs.)**

Text Books:

1) Pandit Ramnandan Shastri, Vedic Mathematics, Arihant Publication

References Books:

1) Kenneth Williams, Discover Vedic Mathematics
2) Rajesh Kumar Thakur, Advanced Vedic Mathematics, Rupa Publication

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Semester- III		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
SEC (Skill Enhancement Course)	**Arc Radius Goba Verification and its Applications**	**02**

COs: On successful completion of this course, students would be able to

- Interpret new concepts to study the geometry
- Recognize answer coming from formulas/theorems are fixed, complete and rational.
- Present new concepts to the world by using these formulas.
- Used to complete the incomplete, approximate concept based on the applications.

Unit	Content
Unit I	The formula of arc radius, Verification of the new formula of Arc radius. **(08 Hrs.)**
Unit II	Introduction, Goba, Circumference of circle, Area of circle, Area of Sector, Straight radius, Arc radius, Straight Diameter, Arc Diameter, Formula of the Volume of the sphere (cubic units), Formula of the Volume of the hemisphere (Cubic units), Volume of Ellipsoid, Formula of the Cube of the Straight radius, Cylinder, Cone, Frustum of the cone, Length of the Arc, Area of shaded ring of a circle, Length of a Circular Arc, Area of Circle Sector. **(08 Hrs.)**

Text Books:

1) Dhananjay Shantaram Janorkar, A Text Book on Arc Radius, Goba Verification and Its Applications, First Edition, OM Publication, Akola, Maharashtra, India

References Books:

1) Shantaram Bapurao Janorkar, "Goba Cha Swayamshidha Sidhanta" (In Marathi language) -15 September 1998, Om Publication, Mahan-444405, India
2) Shantaram Bapurao Janorkar, "Goba Cha Swayamshidha Sidhanta Wa Sutracha Aadharacha Spastikaran" (In Marathi language) - 4 April 2004, Om Publication, Mahan-444405, India
3) Dhananjay Shantaram Janorkar, Web-Site: www.sbjanorkar.com – 10 December, 2014, Om Publication, Mahan- 444405, India
4) Dhananjay Shantaram Janorkar, Internet data.

Programme: M.Sc.-II (Semester-IV), Mathematics
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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-I / Mathematics	**Functional Analysis-II**	06

COs: On successful completion of this course, students would be able to

- Understand the concept of Hilbert spaces normal and unitary operators.
- Explain spectral properties of bounded linear operators
- Understand compact linear operators on normed spaces.
- Acquire knowledge of spectral properties.
- Learn positive operator and square root positive operators and projection operators

Unit	Content
Unit I	Riesz Representation theorem, adjoint of an operator on a Hilbert space, Reflexivity of Hilbert Spaces, self-adjoint operators, normal and unitary operators **(15 Hrs.)**
Unit II	Spectral properties of bounded Linear operators, basic concepts, further properties of solvent and spectrum, use of complex analysis in spectral theory. **(15 Hrs.)**
Unit III	Compact linear operator on normed spaces, further properties of compact linear operators, spectral properties of compact linear operators on normed spaces. **(14 Hrs.)**

Unit IV	Spectral properties of bounded self-adjoint linear operators, further spectral properties of bounded self-adjoint linear operators. **(14 Hrs.)**
Unit V	Positive operator, square root positive operator, projection operators, spectral family. **(14 Hrs.)**

Text Book:

1) E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, New York, 1978.

Reference Books:

1) Serge Lang, Analysis I & II, Addison-Wesley Publishing Company, Inc. 1967.
2) G. Bachman and L. Narici, Functional Analysis, Academic Press,1966.
3) N. Dunford and J.T. Schwartz, Linear Operators, Part-I, Inter science, New York, 1958.
4) R. E. Edwards, Functional Analysis, Holt Rinehart and Winston, New York,1965.
5) C. Goffman and Pedrick, First Course in Functional Analysis, Prentice Hall of India, New Delhi,1987.
6) P. K. Jain, O. P. Ahuja and Khalil Ahmad, Functional Analysis, New Age International (P) Ltd.& Wiley Eastern Ltd., New Delhi, 1997.
7) R. B. Holmes, Geometric Functional Analysis and its Applications, Springer-Verlag,1975.
8) K.K. Jha, Functional Analysis, Students Friends, 1986.

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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-II / Mathematics	**Partial Differential Equations**	**06**

Cos: On successful completion of this course, students would be able to

- Solve the first-order linear and non-linear partial differential equations by using Lagrange's and Charpit Methods respectively.
- Evaluate the solutions of linear partial differential equations of second and higher order with constant coefficients.
- Classify second order PDE Classify the fundamental principles of partial differential equations to solve hyperbolic, parabolic and elliptic equations and solve standard partial differential equations using separation of variable method.
- Evaluate the solutions of heat conduction problem·
- Learn to choose an appropriate method for solving PDE and interpret the qualitative features of solutions.

Unit	Content
Unit I	Curves and Surfaces, Genesis of first order PDE, Classification of Integrals, Linear Equations of the first order, Pfaffian differential Equations, Compatible Systems, Charpit's Method, Jacobi's Method, Integral Surfaces through given curve. **(14 Hrs.)**
Unit II	Quasi-Linear equations, Non-linear first order P.D.E., genesis of second order PDE, Classification second order PDE **(14 Hrs.)**
Unit III	One dimensional Wave equation, Vibrations of an infinite string, Vibrations of Semi-infinite string, Riemann's Method, Vibrations of a string of finite Length. **(15 Hrs.)**

Unit IV	Laplace's Equation, Boundary value problems, Maximum and Minimum Principles, The Cauchy problem, The Dirichlet Problem for the upper half plane, The Neumann problem for the upper half plane, The Dirichlet problem for a circle, The Dirichlet Exterior Problem for a circle, The Neumann problem for a circle, The Dirichlet problem for a Rectangle, Harnack's Theorem, Laplace's Equation-Green function, The Dirichlet problem for half plane, The Dirichlet problem for a circle. **(15 Hrs.)**
Unit V	Heat Conduction Problem**:** Heat Conduction-Infinite rod case, Heat conduction-finite rod case, Duhamel's principle: Wave Equation, Heat conduction equation. Classification in the case of n–variables, Families Of equipotential surfaces, Kelvin's Inversion Theorem **(14 Hrs.)**

Text Book:

1) T. Amarnath: An Elementary course in Partial Differential Equations, 2nd Ed. Narosa Publishing House, New Delhi.

Reference books:

1) I. N. Sneddon: Elements of Partial Differential Equations, McGraw Hill, International Edition, New York.
2) Phoolan Prasad, Renuka Ravindran: Partial Differential Equations, New Age and International Publishers.
3) Lawrence C. Evans: Partial Differential Equations, Vol.19, AMS,1998.
4) R. J. Leveque, Finite difference methods for ordinary and partial differential equations, July-2007

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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-III / Mathematics	**Numerical Analysis**	**06**

Cos: On successful completion of this course, students would be able to

- Practice common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
- Express numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of system of equations, and the solution of differential equations.
- Apply Trapezoidal Rule, Simpson's ⅓ rd Rule, Simpson's ⅜ th rule and find numerical integrated value.
- Solve a different system of linear equations.
- Analyze different methods of Numerical Solution Ordinary Differential Equation.
- Evaluate boundary value problems using the Finite-difference Method.

Unit	Content
Unit I	Solution of Algebric and Transcendental equations: The Bisection Method, The Method False Position, The Iterative Method, Newton-Raphson Method, Secant Method, Muller's Method. System Of Non-linear equation by Iterative Newton-Raphson Method, Rate of Convergence. Solved Problems. **(14 Hrs.)**

Unit II	Finite Differences: Forward and backward Differences, Newton's for formula Interpolation, Central Difference interpolation formula, Stirling' formula, Bessel's formula, Lagrange's interpolation formula, Error in Lagrange's interpolation formula. Hermite Interpolation, Divided Differences and Properties, Spline interpolation. **(14 Hrs.)**
Unit III	Numerical Differentiation and Integration: Numerical Differentiation, error Numerical differentiation, The Cubic Spline Method. Numerical integration: Trapezoidal Rule, Simpson's ⅓ Rule, Simpson's ⅜ Rule, Use of Cubic Splines, Romberg integration. Newton's-Cotes integration formula, Euler-Maclaurin Formula. **(15 Hrs.)**
Unit IV	Solution of system of linear equations: Direct method, Matrix Inversion Method, Gauss Elimination Method, Gauss Jordan Method, Modification of Gauss Method, LU Decomposition, LU Decomposition from Gauss Method, Solution of system by Iterative Methods. The Eigen value Problems, Eigen value asymmetric Tridiagonal matrix. **(14 Hrs.)**
Unit V	Numerical Solution Ordinary Differential Equation: Solution by Taylor's series, Picard's Method of Successive approximations, Euler's Method, error estimate for the Euler's Method, Modified Euler's Method, and Runge-Kutta Method. Simultaneous and Higher-Order equations. Boundary value problems: Finite-difference Method, The Shooting Method, The Cubic Spline Method. **(15 Hrs.)**

Text Book:

1) S. S. Sastry, Introductory Methods of Numerical Analysis, 4th Edition. PHI Learning Pvt. Ltd., New Delhi, 2010

Reference Books:

1) T. M. Karade, Nilay T. Karade: Introductory Numerical Analysis, Einstein Foundation International, Sonu Nilu,. Nov. 2019.
2) Francis Scheid, Schaum's outline Numerical Analysis, Tata McGrawHillEducationPvt.Ltd.,2rd Edition, New Delhi 2009.
3) M. K. Jain, S.R. K. Iyengar and R. K. Jain, Numerical Methods Problems and Solutions, Wiley Eastern Ltd, New Delhi,1994.
4) M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods Problems and Solutions, New Age International Ltd,1996.
5) M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, Newage International publishers, India, 5thEdition,2007.
6) C. F. Gerald and P. O. Wheatley Applied Numerical Analysis, Pearson Education, India, 7thEdition,2008.
7) M. Pal, Numerical Methods for Scientific and Engineering Computation, Narosa Publication.
8) S. D. Comte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic approach, 3rd Edition, McGraw Hill, International BookCompany,1980.
9) F. B. Hildebrand, Introduction to Numerical Analysis, McGraw Hill, NewYork, 1956.
10) C. E. Froberg, Numerical Mathematical Analysis ,2nd Edition, Addison-Wesley,1979.

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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-IV / Mathematics	**Relativistic Cosmology (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Interpret the fundamental equations of dynamical cosmology.
- Develop a different cosmological model of the universe.
- Analyze the derivations of three different types of early universe.

- Compare the derived cosmological model with the actual universe.
- Learn the different kinematical properties of cosmological models.

Unit	Content
Unit I	Einstein Field Equations with Cosmological term, static cosmological models of Einstein and De-sitter, their derivations, properties and comparison with the actual Universe **(14 hrs.)**
Unit II	Cosmological principle, Hubble' s law, Weyl's Postulate, Steady State Cosmological models, Derivation Robertson-Walker Metric, Further Properties. **(14 hrs.)**
Unit III	Motion of particles and light rays in R-W model: Material Particles, Radial motion of a particle, General motion, light rays. The red shift in R-W model, Hubble's and Deceleration parameters. **(15 hrs.)**
Unit IV	Fundamental equation of dynamical cosmology: Density and pressure of present universe, the matter dominated era the present universe, Friedman models: closed model, Flat model, Open model **(14 hrs.)**
Unit V	Space- time metric in the closed isotropic model, Gravitational stability of an isotropic universe, Isotropic space, The red shift, Homogeneous spaces. **(15 hrs.)**

Text Book:

1) Lectures on Relativity: T.M. Karade, et al Einstein Foundation International, Nagpur.

References Books:

1) Introduction to General Relativity -Ronald Adler, Maurice Bazin, Menahem, Schiffer.
2) Mathematical Theory of Relativity: A.S. Eddington, Cambridge University Press,1965.
3) Relativity: The General Theory- J. L. Synge, North Holl and PublishingCompany,1976.
4) The Classical Theory of Fields -I. D. Landau and E. M. Lifshitz, PergamonPress,1980.
5) An Introduction to Riemannian geometry and the Tensor Calculus-C.E. Weatherburn, Cambridge University Press,1950.
6) Classical theory of fields by L. D. Landau and E. M. Lifshitz.

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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V / Mathematics	**Fluid Dynamics-II (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Understand the concepts of gas dynamics
- Explain the viscous flow
- Find the Navier stokes equations of motion of viscous fluid and some solvable problems in viscous flow
- Analyze magneto hydrodynamics
- Verify various dynamical similarities.

Unit	Content
Unit I	Gas Dynamics: Compressibility effects in real fluids, the elements of wave motion, one dimensional wave equation, wave equation in two and in three dimensions, spherical waves, progressive and stationary waves, the speed of sounding as equation of motion of agas, subsonic, sonic and supersonic flows, isentropic gas flow, Reservoir discharge through a channel of varying section. Investigation of maximum mass flow through a nozzle. Shock waves, formation of shock waves, elementary analysis of normal shockwaves **(15 Hrs.)**
Unit II	Viscous Flow: Stress components in are fluid, relation between Cartesian components of stress, translational motion of fluid element, the rate of strain quadric and principle stresses. Some Further Properties Of the rate of strain quadric and principle stresses, stress analysis in fluid motion, relation between stress and rate of strain, the coefficient of viscosity and Laminar flow. **(14 Hrs.)**
Unit III	The Navier stokes equations of motion of a viscous fluid, some solvable problem in viscid flow, steady motion between parallel planes, steady flow through tube of uniform circular cross section, steady flow between concentric rotating cylinders, diffusion of vorticity energy dissipation due to viscosity steady flow past a fixed sphere. **(14 Hrs.)**
Unit IV	Magnetohydrodynamics: Nature of Magnetohydrodynamics, Maxwell's electromagnetic field equation, medium at rest, medium in motion, the equation of motion of a conducting fluid rate of flow of charge, simplification of the electromagnetic field equations, the magnetic Reynolds number, Alfvens theorem, the magnetic body force, Ferraro's laws of isorotation. **(14 Hrs.)**
Unit V	Dynamical similarity, Buckingham p- theorem, Reynold number, Prandt's boundary layer, Boundary layer equations in two dimensions, Blasing solutions, boundary layer thickness, displacement thickness, karmar integral conditions, separation of boundary layer flow. **(14 Hrs.)**

Text Book:

1) R. K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi,1976.

Reference Books:

1) Besaint and A. S. Ramsay, A Treatise on Hydrodynamics, Part-II, CBS Publishers, Delhi, 1988.
2) G. K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.
3) H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York, 1971.
4) M. D. Raisinghania, Fluid Mechanics (With Hydrodynamics), S. Chand and Company Ltd., New Delhi.
5) L. D. Landen and E. M. Lipschitz, Fluid Mechanics, Pargamon Press, London, 1985.
6) F. Chorlton, Text Book of Fluid Dynamics, CBS Publishers, Delhi
7) A. D. Young, Boundary Layers, AIAA Education Series, Washington, DC, 1989.
8) S. W. Yuan, Foundation of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi,

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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V / Mathematics	**Difference Equations-II (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Recognize series solutions about ordinary and regular singular points.
- Apply Power and Frobenius methods.
- Discuss variable coefficient ODE.
- Express the orthogonality of special functions.

Unit	Content
Unit I	The Self-adjoint Second Order Linear Equations: Introduction, Sturman Theory, Green's Functions. Disconjugacy, the Riccati Equations Oscillation. **(14 hrs.)**
Unit II	The Sturm-Liouville Problem: Introduction, Finite Fourier analysis, a non-homogeneous problem. **(14 hrs.)**
Unit III	Discrete Calculation of Variation: Introduction. Necessary Conditions. Sufficient Conditions and Disconjugacy. **(14 hrs.)**
Unit IV	Boundary Value Problems for Nonlinear Equations: Introduction, the Lipschitz case. Existence Of Solutions. Boundary value problems for differential equations. **(15 hrs.)**
Unit V	Partial Differential Equations. Discretization of Partial differential equations. Solution of partial differential equations. **(15 hrs.)**

Text Book:

1) Walter G. Kelley and Allan C. Peterson, Difference Equations An Introduction with Applications, Academic Press, Inc., Harcourt Brace Nora Novich Publishers,1991.

Reference Books:

1) Calvin Ahlbrandt and Allan C. Peterson, Discrete Hamiltonian Systems. Difference Equations, continued Fractions and Riccati Equations: Kluwer, Boston, 1996.
2) Pundit S.K. and Pundit R, Difference Equations, Pragati Prakashan, Meerut,2006.

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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V / Mathematics	**Lie Groups (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Understand topological groups
- Analyze Local groups
- Solve the system of commutator of two infinitesimal transformation and Lie group of transformation explain the significance of Lie algebra

Unit	Content
Unit I	Topological Groups. The Family of Nuclei of a Topological Group. Subgroups and homomorphic images. Connected Topological Groups. **(14 hrs.)**
Unit II	Local Groups: Lie groups. Local lie groups. Analytic Subgroups of Lie Group. One Dimensional Lie Groups. **(14 hrs.)**
Unit III	The Commutator of two infinitesimal transformations. The Algebra of infinitesimal right translations. Lie groups of transformations. **(15 hrs.)**
Unit IV	The lie algebra of sub-group. One parameter subgroup. Taylor' s theorem for Lie groups. The Exponential mapping. **(15 hrs.)**
Unit V	The Exterior algebra of a vector space. The algebra of differential forms. Exterior differentiation. Maurer-Cartan forms. The Maurer Cartan relations. Statement of the lie fundamental theorems. The converses of Lie' s first and second theorems. **(14 hrs.)**

Text Book:

1) P. M. Cohn, Lie Groups, Cambridge University Press,1961.

Reference Books:

1) A. S. Sagle and R. E. Walde, Introduction to Lie Groups and Lie Algebras, Academic Press,1973.
2) Lie Groups and Compact Groups by John F. Price (Cambridge University Press)
3) Theory of Lie Groups by Claude Cherallay (Princeton University Press)

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Semester- IV		
Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-V / Mathematics	**Banach Algebras-II (Optional)**	06

Cos: On successful completion of this course, students would be able to

- Recognize the definition of Banach Algebra and Examples.
- Realize the maximal ideal space and its applications.
- Apply the Gelfand Transforms, the spectral mapping theorem for disc algebra.
- Analyze the C*-algebras, self-adjoint, unitary, normal, positive and projection elements in C*-algebras.

Unit	**Content**
Unit I	Sub algebras of C^* - algebra and the spectrum, the spectral theorem, the continuous functional calculus, positive linear functional and states in C^* - algebras, the GNS construction. **(14 hrs.)**
Unit II	Strong and weak operator topologies, Von Neumann algebras, Monotone Sequence of operator, Range projection. **(14 hrs.)**
Unit III	The Commutant, The double commutant theorem, The Kaplansky Density theorem, L as Von Neumann Algebra, Maximal Abelian Algebras. **(15 hrs.)**
Unit IV	Abelian Von Neumann Algebras, Cycling and Separating vectors, Representation of Abelian Von Neumann Algebras, the L functional calculus, Connectedness of the unitary group. **(14 hrs.)**
Unit V	The Projection lattice, Kaplansky's formula, the centre of a Von Neumann Algebra, Various types of projections, Centrally orthogonal projections, type decomposition. **(15 hrs.)**

Text Book:

1) C. E. Rickart, General Theory of Banach Algebras, Von Nostrand,1960.

Reference Books:

1) M. A. Naimark, Normed Algebras, Groningen, Netherlands,1972.
2) T. W. Palmer, Banach Algebras Vol.-I, Cambridge University Press,1994.

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Programme: M.Sc.-II (Mathematics)

Semester- IV	System of marks and Credit		
Research / Innovative Project / Dissertation	Particulars	Marks	Credit
• Project for Sem-III and IV	Submission	50	3
Submission of Project in Semester-IV on the topics • Research Paper review • Research Paper Analysis • New Research Work	Presentation	25	1
	Viva-voce	25	1
	Total	100	5

Cos: **After completing this course, the students will be able to**

- Aware about the Survey of literature.
- Relates to real world problems through mathematical modelling.
- Formulate the problem and apply the suitable techniques for solution.
- Write the dissertation/ Project.

Appendix-A

INSTRUCTIONS FOR THE PAPER SETTERS

2023-24

Subject: Mathematics

Sr. No.	Program	Marks of Theory Paper	Internal Marks	Total	Instructions
1	**UG-CBCS (Mathematics)**	**60**	**15**	**75**	**Total Units: O5**
	SEM I ,II, III and IV				**Question 1 is compulsory on MCQs for 10 marks** a) Long answers: 06 Marks OR b) Long answers: 06 Marks c) Short answers: 04 Marks OR d) Short answers: 04 Marks
2	**PG- CBCS (Mathematics)**	**80**	**20**	**100**	**Total Units: O5**
	SEM III AND SEM IV				**Question 1 is compulsory on MCQs for 20 marks** a) Long answers: 08 Marks OR b) Long answers: 08 Marks c) Short answers: 04 Marks OR d) Short answers: 04 Marks
3	**PG NEP-2023 (Mathematics)**	**70**	**30**	**100**	**Total Units : 04**
	SEM I AND SEM II				**Question 1 is compulsory on MCQs for 10 marks** a) Long answers: 10 Marks OR b) Long answers: 10 Marks c) Short answers: 05 Marks OR d) Short answers: 05 Marks