Sant Gadge Baba Amravati University, Amravati
Syllabus for M. Sc. II (Mathematics) Sem III and Sem IV (NEP)
Session 2024-25

Faculty: Science and Technology

Programme: M.Sc. Part-II Mathematics (NEP)

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

- Apply knowledge of Mathematics, in all the fields of learning including higher research and its extensions.
- Innovate, invent and solve complex mathematical problems using critical understanding, analysis and synthesis.
- Adjust themselves completely to the demands of the growing field of Mathematics by lifelong learning.
- Effectively communicate about their field of expertise on their activities, with their peer and society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations
- Crack lectureship and fellowship exams approved by UGC like CSIR – NET and SET.
- The Mathematical Software LaTex, Python & Scilab applicable for research.

PSOs
Upon completion of the programme successfully, students would be able to

- Develop problem-solving skills and apply them independently to problems in pure and applied mathematics.
- Understand advanced mathematical knowledge and skills that prepare them to pursue further studies and research.
- Understand advanced and pure mathematical concepts and research.
- Create knowledge, capability in formulating and analyzing mathematical models of real-life applications.
- Analyze the latest advances in applied mathematics such as numerical computations and mathematical modeling in physical sciences.

Employability Potential of the Programme:

After completing M.Sc. in Mathematics, 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 mode. Every business requires financial activity and data management for better improvement and success. Various companies have a position like numerical operation and accountant. 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 job as a Assistant Professor after clearing SLET/ CSIR- NET examination or Ph.D. degree.

2. Junior Research Fellow.
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 researcher 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 deep. 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 of analyzing, researching, using 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 offer 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 good information sheet help company decision-maker to take 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 opportunity** comes from varies area such as finance, wells Fargo, American Express, Deutsche bank, CICNA, Barclay's bank, AIG, JP Morgan, Goldman Sachs, etc.

Syllabus Prescribed from the year 2024-25, PG Programme

Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
FSC	Contemporary Applied Technological Advancements in Research	04

COs:

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

- To understand the Applications of Graph Theory.
- To understand Mathematics in Network Analysis.
- To study the applications of Fourier and Laplace Transform in Differential equations.
- To understand recent trend of General Relativity

Unit	Content
Unit I	Graph in Switching and Coding Theory: Contact Networks, Analysis of contact networks, Synthesis of contact network, Sequential Switching networks, Unit cube and its graph, Graphs in coding theory. **(15 Hrs.)**
Unit II	Network Analysis: Introduction, Definition and Symbols, Networks, Gantt Bar Chart, Critical path method (CPM), Resource levelling of time, PERT. **(14 Hrs.)**
Unit III	Application of Laplace transform in solving ordinary and partial differential equations, applications of Fourier transform in solving partial differential equation. **(15 Hrs.)**
Unit IV	Review of General Relativity and Cosmology, Dark Energy and Dark Matter, Basic of Alternative and Modified Theories of Gravitation, Dynamical properties of cosmological model of universe. **(14 Hrs.)**

Text Book:

- A text book of Contemporary Applied Technological Advancements in Research: V. A. Sharma, S. R. Bhoyar, G. U. Khapekar, V. R. Patil, S. R. Kumbhare, A. N. Rangari.

Reference Books:

(1) Harrison, M. A., Introduction to switching and Automata theory, McGraw-Hill Book Company, New York 1965
(2) Hill, F. J., and G.R Peterson, Introduction to Switching Theory and Logical Design, John Wiley & Jons Inc., New York, 1968.
(3) General Relativity; An Introduction for Physicists: M.P. Hobson, G.P. Efstathiou and A. N. Lasenby, Cambridge University Press, 2006.
(4) Graph Theory with applications to Engineering and Computer Sciences, N. Deo, Prentice Hall of India.
(5) Operation Research: God-Mittal-II Pundir, A Pragati edition, 2018, Meerut
(6) The Scientist and Engineer's Guide to Digital Signal Processing second edition by Steven W. Smith, 1999
(7) Gravitation, Charles W. Misner, Kip S. Thorne and John Archibald Wheeler, W.H. Freeman and Company, San Francisco. 1973.

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-VII / 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.
- Classify operators on 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. **(15 Hrs.)**
Unit II	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. **(14 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. **(15 Hrs.)**
Unit IV	Inner product spaces, Hilbert spaces, orthogonal sets, Bessel's Inequality, complete orthogonal sets, Parseval's identity, structure of Hilbert spaces **(14 Hrs.)**

Text Book:

- 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.

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-VIII / Mathematics	Operations Research	03

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.
- Formulate Linear Programming problems.
- Compute Game Theory Problems.

Unit	**Content**
Unit I	Operations 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. **(12 Hrs.)**
Unit II	Integer Programming, Branch and Bound Technique, Fractional Cut plane method, Goal programming, Advanced techniques in LP (upper bound technique). **(11 Hrs.)**
Unit III	Parametric linear programming, Transportation problem and assignment problems. **(11 Hrs.)**
Unit IV	Game and strategies, two persons 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. **(11 Hrs.)**

Text Book:

- Kanti Swaroop, P. K. Gupta and Manmohan, Operations Research, Sultan Chand &Sons, NewDelhi-2007.

Reference Books:

1) G. Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.

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

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSE-III / Mathematics	General Relativity (Optional)	03

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.
- 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 g44 and V, Einstein equations compared with Poisson equation. (**12 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. **(11 Hrs.)**
Unit III	Schwarzschild interior solutions, field of charged mass point the boundary conditions, Eddington's Form of Form of Schwarzschild Solution. **(11 Hrs.)**
Unit IV	Gravitational Collapse of Spherical Body, gravitational collapse of a dust like sphere, Black Hole, Kerr metric, gravitational collapse of a non-spherical and rotating body. **(11 Hrs.)**

Text Book:

- Elements of General Relativity: T. M. Karade, K. S. Adhav, S. D. Katore, M. S. Bendre, Sonu Nilu Publication, Einstein Foundation International, Nagpur, first edition June-2014.

Reference Books:

1) Introduction to General Relativity - Ronald Adler, Maurice Bazin, Menahem, Schiffer, 2nd Edition, McGraw Hill Company.
2) Mathematical Theory of Relativity: A.S. Eddington, Cambridge University Press,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, PergamonPress,1980.
5) An Introduction to Riemannian Geometry and the Tensor Calculus
6) C. E. Weatherburn, Cambridge University Press,1950.

7) Classical Theory of Fields by L. D. Landau and E. M. Lifshitz.

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSE-III / Mathematics	Fluid Dynamics (Optional)	03

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.
- Discuss Euler's Equation of Motion and Bernoulli's Equation.
- Recognize the use of the equation of state of substance, the first law of Thermodynamics, internal energy of a gas.

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. Condition Sata Rigid Boundary, general analysis of fluid motion. **(12 Hrs.)**
Unit II	Pressure of motion of a fluid: Pressure at a point in a fluid at rest. Pressure at a point in a moving fluid, conditions a boundary of two inviscid immiscible liquids, 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. **(11 Hrs.)**
Unit III	Sources, sinks and Doublets, images in a rigid infinite plane. Images in a 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. **(11 Hrs.)**
Unit IV	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. Iso-thermal Adiabatic and Isentropic Process. **(11 Hrs.)**

Text Book:

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

Reference 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, Pergamon 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

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSE-III / Mathematics	Difference Equations-I (Optional)	03

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 behavior 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. **(12 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. **(11 Hrs.)**
Unit III	The Z-transform: Properties, initial and final value theorems, partial sum theorem, convolution theorem. Inverse transforms, solution of difference equation with constant coefficients by Z-transforms. **(11 Hrs.)**
Unit IV	Stability Theory: Initial value problems for linear systems. Stability of linear systems. Stability of non-linear system. Chaotic behaviour. **(11 Hrs.)**

Text Book:

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

Reference 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: A Friendly Guide to Wavelets, Birkhauser,1994.

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
Practical – I/ Mathematics	Practical on DSC- VIII (Operations Research)	04

COs

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

- Formulate and obtain the optimal solution for Linear Programming problems.
- To understand a basic thoughtfulness for linear programming problem.

- Apply the technique of LPP to solve real world problem.
- Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems.
- Recognize and solve game theory and assignment problems.

Sr. No.	List of Practical's to be covered	No. of Examples
1	Introduce LPP and to solve the LPP by using graphical Method.	03
2	To Solve the LPP by using simplex method.	03
3	To write algorithm and solve LPP by using Big M method.	03
4	Use Branch and Bound method to solve the integer programming problem.	03
5	Write the algorithm of fractional cut plane method and solve integer LP problem.	03
6	To find the optimum solution of goal programming problem by using simplex method.	03
7	To find an initial basic feasible solution of transportation problem by North west corner rule	03
8	To find an initial basic feasible solution of transportation problem by Vogel's approximation method.	03
9	To solve assignment problems.	03
10	To solve the game problem graphically.	03
11	To solve the game problem by using dominance property.	03
12	To solve the game problem by using linear programming technique.	03
Practical Assessment (100 Marks)	Internal Practical Assessment **(50 Marks)**	**1.** Practical Record- **20 Marks** **2.** Internal Assessment – **30 Marks**
	External Practical Assessment **(50 Marks)**	**3.** Practical Perform (Any two) – **30 Marks** **4.** Viva- **20 Marks**

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject **Title of the Course/Subject** **(Total Number of Periods/week)**

Practical - II / Mathematics Programming with Mathematica 04

COs:

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

- To understand how to use Mathematica for Mathematical Modelling and Simulation
- To improve problem-solving skills
- To understand symbolic computation
- To understand Numerical computation
- To understand graphical representations of functions

Unit-I	**Numerical Calculations and Building Up Calculations:** Arithmetic, Exact and Approximate Results, Some Mathematical Functions, Arbitrary-Precision Calculations, Complex Numbers, Getting Used to *Mathematica*, Mathematical Notation in Notebooks, Using Previous Results, Defining Variables, Making Lists of Objects, Manipulating Elements of Lists, The Four Kinds of Bracketing in *Mathematica*, Sequences of Operations. **(15 Hrs.)**
Unit-II	**Algebraic Calculations and Symbolic Mathematics:** Symbolic Computation, Values for Symbols, Transforming Algebraic Expressions, Simplifying Algebraic Expressions, Advanced Topic: Putting Expressions into Different Forms, Advanced Topic: Simplifying with Assumptions, Picking Out Pieces of Algebraic Expressions, Controlling the Display of Large Expressions, - The Limits of *Mathematica*, Using Symbols to Tag Objects, Basic Operations, Differentiation, Integration, Sums and Products, Equations, - Relational and Logical Operators, Solving Equations, , Inequalities, - Differential Equations, Power Series, Limits, Integral Transforms,

	Recurrence Equations, - Packages for Symbolic Mathematics, Advanced Topic: Generic and Non-Generic Cases, Mathematical Notation in Notebooks. **(14 Hrs.)**
Unit-III	**Numerical Mathematics and Functions and Programs:** Basic Operations, Numerical Sums, Products and Integrals, - Numerical Equation Solving, - Numerical Differential, Equations- Numerical Optimization, - Manipulating Numerical Data, - Statistics, Defining Functions, Functions as Procedures, Repetitive Operations, Transformation Rules for Functions. **(15 Hrs.)**
Unit-IV	**Graphics and Sound:** Basic Plotting, Options, Redrawing and Combining Plots, Advanced Topic: Manipulating Options, Contour and Density Plots, - Three-Dimensional Surface Plots, converting between Types of Graphics, Plotting Lists of Data, Parametric Plots, Some Special Plots, Special Topic: Animated Graphics, Sound. **(14 Hrs.)**

Text Book:

- Stephen Wolfram, *The Mathematica Book*, 5th ed. (Wolfram Media, 2003)

Sr. No.	List of Practical's to be covered
	Group A
1	Design and execute a program to define variables and find the sum, difference, multiplication and division of two or more numbers variables.
2	Design and execute a program to find the sum, difference, multiplication and division of two or more complex variables.
3	Design and execute a program to find derivative and integration of algebraic equations.
4	Design and execute a program to find derivative and integration of trigonometric functions.
5	Design and execute a program to solve multiple integrals of different variables with different range.
6	Design and execute a program to solve algebraic equation in one variable with heights power is less than five.
7	Design and execute a program to solve simultaneous equations for two or more variables.
8	Design and execute a program to solve differential equation.
9	Design and execute a program to find the limit of functions.
10	Design and execute a program to plot graphs of functions.
	Group B
1	Design and execute a program to define variables, find the sum, difference, multiplication and division of two or more numbers variables with higher power and find numerical value of equations.
2	Design and execute a program to find integration of algebraic equations. Calculate its numerical value and plot graphs of functions before and after integration.
3	Design and execute a program to find integration of trigonometric functions. Calculate its numerical value and plot graphs of functions before and after integration.
4	Design and execute a program to find derivative of algebraic equations. Calculate its numerical value and plot graphs of functions before and after integration.
5	Design and execute a program to find derivative of trigonometric functions. Calculate its numerical value and plot graphs of functions before and after integration.
6	Design and execute a program to Fourier transform and inverse Fourier transform of functions.
7	Design and execute a program to find Laplace transform and inverse Laplace transform a function.
8	Design and execute a program to plot 2D, 3D graphs of functions.
9	Design and execute a program to solve differential equations. Find numerical values of solutions of differential equations and plot graphs of solutions of differential equation.
10	Design and execute a program to find minimum value, maximum value, local minimum, local maximum, mean and median of functions.

Distribution of Practical Marks		
Internal Practical Marks	**Allotted Marks**	**Total Marks**
I. Internal Assessment	30	50
II. Practical Record	20	
External Practical Marks		
III. Program design/Performed (Any one of each group A & B)	30	50
IV. Viva Voce	20	
		100

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Programme: M.Sc.-II (Mathematics)

Semester- III

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
Practical / Mathematics	Research Project Phase-I	06

COs:

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

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

Semester-III	**Particulars**	**System of marks and Credit**			
Research/Innovation Project (Literature		**Maximum Marks**		**Total Credit**	**Minimum Passing**
		Practical Internal	**Practical External**		
Research Project Phase-I Content of Project: 1. Identify topics 2. Review of literature 3. Formulate research questions/ hypothesis 4. Research design/methodology	Preliminary Submission	30	---	3	25
	Viva-voce	20	---	1	
	Total Marks	**50**		**4**	**25**

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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-IX / Mathematics	Partial Differential Equations	04

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, Charpits and Jacobi's 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 one dimensional wave equation 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, Jacobi's Method, Integral Surfaces through given curve. **(15 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. **(14 Hrs.)**

Text Book:

- T. Amaranath: 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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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC-X / Mathematics	Numerical Analysis	04

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.
- Analyze different methods of Numerical Solution Ordinary Differential Equation.
- Evaluate boundary value problems using the Finite-difference Method.

Unit	**Content**
Unit I	Solution of Algebraic and Transcendental equations: The Bisection Method, The Method False Position, The Iterative Method, Newton-Raphson Method, Secant Method. System Of Nonlinear equation by Iterative Newton-Raphson Method. Solved Problems. **(15 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. Hermite Interpolation. **(14 Hrs.)**
Unit III	Numerical Differentiation and Integration: Numerical Differentiation. Numerical integration: Trapezoidal Rule, Simpson's 1/3 Rule, Simpson's 3/8 Rule, Romberg integration, Euler-Maclaurin Formula. **(15 Hrs.)**
Unit IV	Numerical Solution Ordinary Differential Equation: Solution by Taylor's series, Picard's Method of Successive approximations, Euler's Method, Modified Euler's Method, and Runge-Kutta Method. Simultaneous and Higher-Order equations. Boundary value problems: Finite-difference Method, The Cubic Spline Method. **(14 Hrs.)**

Text Book:

- S. S. Sastry, Introductory Methods of Numerical Analysis, 4th edition, PHI Learning Pvt. Ltd., New Delhi, 2010

Reference Books:

1) Francis Scheid, Schaum's outline Numerical Analysis, Tata McGraw Hill Education Pvt. Ltd., 2rd Edition, New Delhi 2009.
2) M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods Problems and Solutions, Wiley Eastern Ltd, New Delhi,1994.
3) M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods Problems and Solutions, New Age International Ltd,1996.
4) M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International publishers, India,5thEdition,2007.
5) C. F. Gerald and P. O. Wheatley Applied Numerical Analysis, Pearson Education, India, 7th Edition, 2008.
6) M. Pal, Numerical Methods for Scientific and Engineering Computation, Narosa Publication.
7) S. D. Comte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic approach, 3rd Edition, McGraw Hill, International BookCompany,1980.
8) F. B. Hildebrand, Introduction to Numerical Analysis, McGraw Hill, New York, 1956.
9) C. E. Froberg, Numerical Mathematical Analysis, 2nd Edition, Addison-Wesley, 1979.
10) T.M. Karade & N.T. Karade, Introductory Numerical Analysis, Sonu Nilu Publication, 2022.

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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSC- XI / Mathematics	Advanced Mechanics	03

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
- Discuss Euler's equation of motion for rigid body.
- Describe the motion of a mechanical system using Hamilton-Jacobi equation.
- Convince the mechanism of canonical transformation.

Unit	Content
Unit I	Hamilton's Principle, Lagrange's Equations for Non-Holonomic System, Routh's procedure, Least Action Principle. **(12 Hrs.)**
Unit II	Rigid body, generalized co-ordinates of a rigid body, Eulerian angles, Euler's theorem, finite rotations, infinitesimal rotations. **(11 Hrs.)**
Unit III	The Hamilton Equation of Motion: Legendre Transformation and Hamilton Equation of Motion, Cyclic Coordinate and Conservation Theorem, The Hamiltonian Formulation of Relativistic Mechanics, the equations and example of canonical transformation. **(11 Hrs.)**
Unit IV	Poison bracket and other canonical equivalent equation of motion, infinite decimal canonical transformation and cartesian theorem in poison bracket formulation, angular momentum, Poison bracket relation, symmetric group of mechanics system, Liouville's theorem. **(11 Hrs.)**

Text Book:

- Goldstein H, Classical Mechanics, Narosa Publishing House, (Second edition) (2018).

Reference Books:

1) T.M. Karade, G. S. Khadekar, Lectures on Advanced Mechanics, Sonu-Nilu publication
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 (2009).
4) Gupta, Kumar and Sharma, Classical Mechanics, Pragati Prakashan (2012).
5) I.D. Landau and E.M. Lifchitz, Vol. I third edition, Perguman press, New Delhi (2000).
6) L.M. Katkar, Classical Mechanics (Mathematics), Shivaji University Kolhapur, (2007).
7) Classical Mechanics by J.C. Upadhyaya.

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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
DSE-IV / Mathematics	Relativistic Cosmology (Optional)	03

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.

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. **(12 Hrs.)**
Unit II	Cosmological principle, Hubble' s law, Weyl's Postulate, Steady State Cosmological models, Derivation Robertson-Walker Metric, Further Properties. **(11 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. **(11 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. **(11 Hrs.)**

Text Book:

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

Reference 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 Holland Publishing Company,1976.
4) The Classical Theory of Fields -I.D. Landau and E. M. Lifshitz, Pergamon Press,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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Programme : M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject **Title of the Course/Subject** **(Total Number of Periods/week)**

DSE-IV / Mathematics Difference Equations- II (Optional) 03

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, Sturmian Theory, Green's Functions. Disconjugacy, the Riccati Equations, Oscillation. **(12 Hrs.)**
Unit II	The Sturm-Liouville Problem: Introduction, Finite Fourier analysis, A Non-homogeneous problem. **(11 Hrs.)**
Unit III	Discrete Calculation of Variation: Introduction. Necessary Conditions. Sufficient Conditions and Disconjugacy. **(11 Hrs.)**
Unit IV	Boundary Value Problems for Nonlinear Equations: Introduction, the Lipschitz case. Existence Of Solutions. Boundary value problems for differential equations. **(11 Hrs.)**

Text Book:

- 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 Pundir R., Difference Equations, Pragati Prakashan, Meerut, 2006.

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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject **Title of the Course/Subject** **(Total Number of Periods/week)**

DSE- IV / Mathematics Functional Analysis-II (Optional) 03

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.

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. **(12 Hrs.)**
Unit II	Spectral properties of bounded Linear operators, basic concepts, further properties of solvent and spectrum, use of complex analysis in spectral theory. **(11 Hrs.)**
Unit III	Compact linear operator on normed spaces, further properties of compact linear operators, spectral properties of compact linear operators on normed spaces. **(11 Hrs.)**
Unit IV	Spectral properties of bounded self-adjoint linear operators, further spectral properties of bounded self-adjoint linear operators. **(11 Hrs.)**

Text Book:

- 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, NewYork,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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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
Practical-I / Mathematics	Practical based on DSC- X (Numerical Analysis)	04

COs

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

- Apply appropriate numerical methods to solve the problem with most accuracy.
- Use relevant numerical techniques for interpolation with equal and unequal intervals by using various central difference formulae.
- Be able to find the derivatives using Newton's forward difference formula, Newton's backward difference formula.
- Be able to find the find the solution of ordinary differential equation of first order by Euler, Taylor and Runge-Kutta Method.

Sr. No.	List of Practical's to be covered	No. of Examples
1	To find the root of non-linear equation using Bisection Method.	03
2	To Solve simultaneous non-linear equations using Newton Raphson method.	03
3	To find the root of non-linear equation using Regula-Falsi Method.	03
4	Numerical solution of central difference interpolation by using Lagrange interpolation method.	03
5	To find the value of function f(x) by using Gauss's forward formula.	03
6	To find Hermite's polynomial of the tabular data.	03
7	To find numerical differentiation and Errors in numerical differentiation.	03
8	Numerical solution of integrals using Trapezoidal method.	03

9	Numerical evaluation of integrals using Simpson's method.		03
10	Numerical Solution of initial value problem using Euler's method.		03
11	Numerical Solution of initial value problem using Runga Kutta method.		03
12	To solve boundary value problem by Finite-difference approximation method.		03
Practical Assessment (100 Marks)	Internal Practical Assessment **(50 Marks)**	**1.**Practical Record- **20 Marks** **2.** Internal Assessment – **30 Marks**	
	External Practical Assessment **(50 Marks)**	**5.** Practical Perform (any two) – **30 Marks** **6.** Viva- **20 Marks**	

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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject **Title of the Course/Subject** **(Total Number of Periods/week)**

Practical -II/ Mathematics Programming on Python 04

COs:

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

- Install Python Software and execute the basic concepts of programming.
- able to understand Conditional Statement and Looping.
- perform basic mathematical operation using Python Software.
- analyse different types of data using plotting of functions in Python.
- handle Object Oriented Programming.
- understand the features of function and strings.
- Coding simple solutions to numeric and string problems.

Unit	Content
Unit-I	**Introduction to Python** Numerous Features of Python: Type and Run, Mixing, Dynamic Typing, Built in Object Types, Libraries and Tools. Chronology and uses, Installation of Anaconda, Basic data types revisited, String, Lists and Tuples. **(15 Hrs.)**
Unit-II	**Conditional Statement and Looping** Conditional Statement: if, if-else, and if-elif-else construct, The if-elif-eise Ladder, Logical Operation, The Ternary Operator, The great Construct, Examples. Looping: While, Patterns, Nesting and Application of loops in lists. **(14 Hrs.)**
Unit-III	**Functions and String** Features of a functions: Modular Programming, Reusability of Code, Manageability, Basic Terminology (Name of function, Arguments, Return Value), Invocation (Definition), Type of functions, implementing search, Scope, Recursion (Rabbit Problem, Disadvantage of using recursion). Strings: The Use of 'For' and 'White', String Operator, Functions for String Handling. (**15 Hrs.)**
Unit-IV	**Introduction to Object Oriented Paradigm:** Creating News Types, Attributes and Functions, Element of Object- Oriented Programming (Class, Object, Encapsulation, Data Hiding, Inheritance, Polymorphism, Reusability) **Classes and Objects:** Defining a Class, Creating an Object, Scope of Data Members, Nesting, Constructor, Constructor Overloading, Destructors. **(14 Hrs.)**

Text Book:

- Ms. Leetavathi, Dr. V. Kavitha, Dr. A. Syed Musthafa: A text Book on Python Programming, Notion Press 2022, Chennai.

- E. Balguruswami: Introduction to computing and python programming,

Reference Books:

(1) Rupesh Narse: Python Programming, all India council for Technical Education New Delhi.
(2) Dr. R. Nageswara Rao: Core Python Programming, Dreamtech press.

Sr. No.	List of Practical's to be covered
	Group A
1	Create a program that asks the user to enter their name and their age. Print out a message addressed to them to that tells them the year that they will turn 100 years old.
2	Enter the number from the user and depending on whether the number is even or odd. Print out an appropriate message to the user.
3	Write a program to generate the Fibonacci series.
4	Write a function that reverses the user defined value.
5	Write a function to check the input value is Armstrong and also write the function for Palindrome.
6	Write a recursive function to print the factorial for a given number.
7	Write a function that takes a character (i.e. a string of length 1) and returns True if it is a vowel False otherwise.
8	Define a function that computes the length of a given list or string.
	Group B
1	Write a program that takes two lists and returns True if they have at least one common member.
2	Write a Python program to print a specified list after removing 0^{th}, 2^{nd}, 4^{th} and 5^{th} elements.
3	Write Python program a clone or copy a list.
4	Write a Python Script to sort (ascending and descending) a dictionary by value.
5	Write a Python Script to concatenate following dictionaries to create new one dic1= {1:10, 2:20} dic2= {3:30, 4:40} dic3= {5:50, 6:60}
6	Write a Python program to sum all the items in the dictionary.
7	Write a program in class enter any string and if any number presents in to return false otherwise true.
8	Write a program in class concatenate two list items.

Distribution of Practical Marks		
Internal Practical Marks	**Allotted Marks**	**Total Marks**
I. Internal Assessment	30	50
II. Practical Record	20	
External Practical Marks		
III. Program design/Performed (Any one of each group A & B)	30	50
IV. Viva Voce	20	
		100

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Programme: M.Sc.-II (Mathematics)

Semester- IV

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods/week)**
Practical / Mathematics	Research Project Phase-II	10

COs:

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

- aware about the survey of literature.
- related to real world problems through mathematical modelling.
- formulate the problem and apply the suitable techniques for solution
- write the dissertation /Project

Semester-IV	**Particulars**	**System of marks and Credit**			
		Maximum Marks		**Total Credit**	**Minimum Passing**
		Practical Internal	**Practical External**		
Research/Innovation Project /Dissertation					

Research Project Phase-II	Submission	75	---	3	75
Submission of Project on the topics Research paper review/ Research paper analysis/ New Research Work	Presentation	---	40	2	
	Viva-voce	---	35	1	
	Total Marks	**150**		**6**	**75**