CENTRE FOR DISTANCE AND ONLINE EDUCATION

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI – 620 024.

M.Sc. Mathematics - CHOICE BASED CREDIT SYSTEM –

LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(For the candidates admitted from the academic year 2026-27 onwards)

Sem	Course	Course Title	Credit	Exam Hrs	Marks		Total
					Int.	Ext.	
I	Core Course – I (CC)	Linear Algebra	5	3	25	75	100
	Core Course – II (CC)	Real Analysis	5	3	25	75	100
	Core Course – III (CC)	Ordinary Differential Equations	5	3	25	75	100
	Core Course – IV (CC)	Optimization Techniques	5	3	25	75	100
	Elective Course – I (EC)	Graph Theory	4	3	25	75	100
	TOTAL		**24**				**500**
II	Core Course – V (CC)	Complex Analysis	5	3	25	75	100
	Core Course – VI (CC)	Algebra	5	3	25	75	100
	Core Course – VII (CC)	Partial Differential Equations	5	3	25	75	100
	Elective Course – II (EC)	Classical Dynamics	4	3	25	75	100
	Non-Major Elective – I (NME) (For other department students)		2	3	25	75	100
	TOTAL		**21**				**500**

SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES

Sl. No.	Types of the Courses	No. of Courses	No. of Credits	Marks
1.	Core Courses	13	65	1300
2.	Elective Courses	4	16	400
3.	Project	1	5	100
4.	Non-Major Elective Courses	2	4	200
	Total	**20**	**90**	**2000**

Note:

Project :100 Marks
Dissertation : 80 Marks (Internal Evaluation: 40 Marks & External Evaluation: 40 Marks)
Viva Voice : 20 Marks

Core Courses - 13
Elective Courses - 4
Non-Major Elective Courses - 2
Project - 1

Note:

1. Theory	Internal	25 marks	External	75 marks
2. Non-Major Elective Courses	Internal	25 marks	External	75 marks

4. Separate passing minimum is prescribed for Internal and External
   a) The passing minimum for CIA shall be 40% out of 25 marks (i.e. 10 marks)
   b) The passing minimum for University Examinations shall be 40% out of 75 marks (i.e. 30 marks)
   c) The passing minimum not less than 50% in the aggregate.

Question paper pattern:

10 questions compulsory 10 × 02 = 20 Marks (2 from each unit)

5 questions 05 × 05 = 25 Marks (either or, one from each unit)

3 questions from 5 03 × 10 = 30 Marks (one question from each unit)

Total 75 Marks

CIA components:

Test - 15 Marks
Seminar - 5 Marks
Assignment - 5 Marks

Reference/Text Books contain the following details:

I. Name of the Author
II. Title of the Book
III. Name of the Publisher
IV. Year

Programme Outcomes:

- Master Degree Programme in Mathematics will meet the present day needs of academic and Research, Institutions and Industries.
- Students may acquire depth knowledge in Algebra, Analysis, Topology, Functional Analysis, Optimization Techniques and Graph Theory which will motivate the students to go for higher studies/research in Mathematics.
- Inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions.
- Prepare students for pursuing research or careers in mathematical sciences and applied fields.
- Equip the student with skills to analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof.

Programme Specific Outcomes:

- Mastery of Fundamental Mathematical Concepts (Algebra, Analysis, Geometry)
- Will gain the ability to understand and deal with abstract concepts
- Communicate mathematical concepts effectively
- Ability to think critically and creatively
- Analyze and model real world problems based on mathematical principles
- Ability to solve problems which are modeled
- Communicate the solutions in rigorous mathematical language
- Ability to progress independently and ethically

Employability Opportunities:

After completing M.Sc. Mathematics programme, students can

- proceed higher studies and become an academician such as professors etc.
- be a scientific officer on ISRO, DRDO, NAL.
- play a big role in Information and Communication Technology.
- be a Data science modelers.
- be a Quantitative Risk Analyst.
- be an interest rate trading strategist.
- be an operational researchers.
- become a crypto-engineer.
- be a professional in investment banking.
- clear any eligible competitive examination and become a state or central government employee.

Year: I		**Semester:** I

CORE COURSE I
LINEAR ALGEBRA

Objectives:

1. To give the students a thorough knowledge of the various aspects of Linear Algebra
2. To train the students in problem-solving as a preparatory for competitive exam.

UNIT – I

Matrices: Systems of linear Equations - Matrices and Elementary Row operations -Row-reduced echelon Matrices - Matrix Multiplication - Invertible Matrices- Bases and Dimension. (Only revision of Vector spaces and subspaces).

UNIT – II

Linear transformations: The algebra of linear transformations - Isomorphism of Vector Spaces -Representations of Linear Transformations by Matrices - Linear Functionals - The Transpose of a Linear Transformation.

UNIT – III

Algebra of polynomials: The algebra of polynomials - Lagrange Interpolation - Polynomial Ideals -The prime factorization of a polynomial.

UNIT – IV

Determinants: Permutations and the uniqueness of determinants – Additional properties of determinants.

UNIT – V

Diagonalization: Invariant subspaces - Simultaneous triangulation and simultaneous Diagonalization Direct-sum Decompositions - Invariant Direct sums – Primary Decomposition theorem.

TEXT BOOK(S)

1. Kenneth Hoffman and Ray Alden Kunze, Linear Algebra, Second Edition, Prentice Hall of India Private Limited, New Delhi, 1975.
   - UNIT – I - Chapter 1 & 2 1.2-1.6 and 2.3
   - UNIT – II - Chapter 3 (omit 3.6)
   - UNIT – III - Chapter 4 & 5 4.1 - 4.5 and 5.1 - 5.2
   - UNIT – IV - Chapter 5 5.3, 5.4
   - UNIT – V - Chapter 6 6.4 - 6.8

REFERENCE BOOK(S)

1. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice-Hall of India Ltd, 2004.
2. V. Krishnamurthy, V.P. Mainra, J.L. Arora, Introduction to Linear Algebra,East West Press Ltd, 1985.
3. A.R. Rao, P. Bhimashankaram, Linear Algebra, Second Edition, Tata McGraw Hill, 2000.
4. Edgar G.Goodaire,Linear Algebra-Pure & Applied World Scientific,Cambridge University Press India Ltd, 2014.

Course Outcomes: At the end of the course, students will be able to

1. Realise that the subject evolves as a generalization of solving a system of linear equations.
2. Discuss in detail the basic concepts of Linear dependence, basis and dimension of a vector space. The students will be able to demonstrate how the geometric ideas turns into rigorous proofs.
3. Master the dimension formula and rank and nullity theorem which are often exploited.
4. Capture the idea of producing lot of structure preserving maps (Linear transformations). Further the study of algebras of linear maps would be accomplished.
5. Having got trained in numerous examples the student realizes the

isomorphic theory of Linear transformations and matrices.

6. Learn the theory of determinants and put them in practice.
7. Understand that the central theme of structure theory of linear maps is to decompose the given vector space as a direct sum of generalized the Eigen spaces using the given map on it.
8. Understand that linear Algebra plays a fundamental role in many areas of mathematics including Algebra, Geometry, Functional analysis and which finds widest application in Physics, Chemistry and elsewhere.

e-BOOK(S)

1. https://joshua.smcvt.edu/linearalgebra/book.pdf
2. https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2012/02/Linear-Algebra-Kuttler-1-30-11-OTC.pdf

Year: I		**Semester:** I

CORE COURSE II

REAL ANALYSIS

Objectives:

1. To enable the students to learn the basic concepts of Real Analysis and techniques in Analysis to prepare for the advanced courses like Functional Analysis and Advanced Analysis.

UNIT – I

The Real and Complex Number Systems: Introduction – Ordered sets – Fields– The Real Field – Extended Real Number system–The Complex Field – Euclidean Spaces. **Basic topology:** Finite, countable and uncountable sets – Metric Spaces – Compact sets – Perfect sets – Connected sets.

UNIT – II

Numerical Sequences: Convergent Sequences – Sub-sequences – Cauchy Sequences – Upper and Lower Limits – Some Special Sequences – Series– Series of Non-Negative Terms. **Numerical Series:** The Number e – The Root and Ratio Test – Power Series – Summation by Parts – Absolute Convergence- Addition and Multiplication of Series - Rearrangements.

UNIT – III

Continuity: Limits of Functions - Continuous Functions – Continuity and Compactness – Continuity and Connectedness – Discontinuities – Monotonic Functions – Infinite Limits and Limits at Infinity.

UNIT – IV

Differentiation: The Derivative of a Real Function – Mean Value Theorems – The Continuity of Derivatives – L'Hospital's Rule – Derivatives of Higher Order – Taylor's Theorem – Differentiation of Vector Valued Functions.

UNIT – V

The Riemann-Stieltjes Integral: Definition and existence of the integral – Properties of the Integral – Integration and Differentiation – Integration and vector valued functions

TEXT BOOK(S)

1. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition Tata McGraw-Hill 1985.

UNIT – I	- Chapter 1: Sec 1.1 – 1.38 & Chapter 2: Sec 2.1 – 2.47
UNIT – II	- Chapter 3: Sec 3.1 – 3.55
UNIT – III	- Chapter 4: Sec 4.1 – 4.34
UNIT – IV	- Chapter 5: Sec 5.1 – 5.19
UNIT – V	- Chapter 6: Sec 6.1 – 6.26

REFERENCE BOOK(S)

1. Tom. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1997.
2. R. G. Bartle, D. R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, New York, 1982.
3. Kenneth A. Ross, Elementary Analysis: The Theory of Calculus, Springer NewYork, 2004.
4. N. L.Carothers, Real Analysis, Cambridge University Press, UK, 2000.
5. S. C. Malik, Mathematical Analysis,Willey Eastern Ltd, NewDelhi, 1985.
6. K. R. Stromberg, An Introduction to Classical Real Analysis, Wadsworth, 1981.
7. H. L. Royden, Real Analysis, Third Edition, Macmillan Publishing Company, New Delhi, 1988.

Course Outcomes: At the end of the course, students will be able to

1. Describe fundamental properties of the real numbers that lead to the formal development of real analysis.
2. Demonstrate an understanding of limits ad how that are used in

sequences.

3. Demonstrate an understanding of limits ad how that are used in series.
4. Demonstrate an understanding of limits ad how that are used in sequences Examine and recognize the continuity of real functions.
5. Demonstrate an intuitive and computational understanding of set theory, Continuity and solving application problems. This will be assessed through homework, class quizzes and tests, and a final exam.

e-BOOK(S)

1. https://s2pnd-matematika.fkip.unpatti.ac.id/wp-content/uploads/2019/03/Real-Analysis-4th-Ed-Royden.pdf
2. http://www.freebookcentre.net/maths-books-download/gotoweb.php?id=9633

Year: I		**Semester:** I

CORE COURSE III
ORDINARY DIFFERENTIAL EQUATIONS

Objectives:

1. To give an in-depth knowledge of differential equations and their applications.
2. To study the existence, uniqueness, stability behavior of the solutions of the ODE.

UNIT – I

The general solution of the homogeneous equation– The use of one known solution to find another – The method of variation of parameters – Power Series solutions.

UNIT – II

A review of power series – Series solutions of first order equations – Second order linear equations; Ordinary points - Regular Singular Points – Gauss's hypergeometric equation – The Point at infinity.

UNIT – III

Legendre Polynomials – Bessel functions – Properties of Legendre Polynomials and Bessel functions.

UNIT – IV

Linear Systems of First Order Equations – Homogeneous Equations with Constant Coefficients – The Existence and Uniqueness of Solutions of Initial Value Problem for First Order Ordinary Differential Equations – The Method of Solutions of Successive Approximations and Picard's Theorem.

UNIT – V

Oscillation Theory and Boundary value problems – Qualitative Properties of Solutions – Sturm Comparison Theorems – Eigen values, Eigen functions and the Vibrating String.

TEXT BOOK(S)

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, TMH, New Delhi, 1984.

UNIT – I	- Chapter 3: Sections 15, 16, 19
UNIT – II	- Chapter 5 : Sections 25 to 31
UNIT – III	- Chapter 6: Sections 32 to 35
UNIT – IV	- Chapter 7: Sections 37, 38 and Chapter 11: Sections 55, 56
UNIT – V	- Chapter 4: Sections 22 to 24

REFERENCE BOOK(S)

1. W.T. Reid, Ordinary Differential Equations, John Wiley & Sons, New York, 1971.
2. E.A. Coddingtonand N. Levinson, Theory of Ordinary Differential Equaitons, McGraw Hill Publishing Company, New York, 1955.

Course Outcomes: At the end of the course, students will be able to

1. Find the general solution of the first order linear homogeneous equations.
2. Understand the utility of the theory of power series which is studied in Real Analysis course through solving various second order differential equations.
3. Get introduced to the Hypergeometric functions which arises in connection with solutions of the second order ordinary differential equations with regular singular points.
4. Solve the problems arises in Mathematical physics using properties of special functions.
5. Understand the importance of studying well-posedness of the problem namely existence, uniqueness and continuous dependence of first order differential equations through Picard's theorem.
6. Understand the utility of the concepts from linear algebra and analysis in

the study of system of first order equations.

7. Discuss the Qualitative properties of solutions of first and second order equations. Also they will be able to work on numerous problems using comparison theorem in Sturm Liouville problems.
8. Learn the nature of solutions which involves critical points.

e-BOOK(S)

1. http://www.freebookcentre.net/maths-books-download/gotoweb.php?id=8714
2. https://s3.amazonaws.com/open-bookshelf-content/Open+Textbook+Library/URI/urn%3Auuid%3Ae46a68f9-3e84-4999-b9f6-18c3dfb2faca/Ordinary+Differential+Equations.pdf

Year: I		**Semester:** I

CORE COURSE IV
OPTIMIZATION TECHNIQUES

Objectives:

1. To provide insights into structures and processors that operations research can offer and the enormous practical utility of its various techniques.
2. To explain the concepts and simultaneously to develop an understanding of problem solving methods based upon model formulation, solution procedures and analysis.

UNIT – I

Linear Programming Problem – Pure and Mixed Integer Programming Problems – Gromory's All I.P.P. Method – Construction of Gomory's Constraints - Fractional Cut Method-All Integer LPP – Fractional Cut Method-Mixed Integer LPP – Branch and Bound Method – Applications of Integer Programming.

UNIT – II

Dynamic Programming – The Recursive Equation Approach – Characteristics of Dynamic Programming – Dynamic Programming Algorithm – Solution of Discrete DPP – Applications.

UNIT – III

Goal Programming – Categorisation of Goal Programming – Formulation of Linear Goal Programming Problem – Graphical Goal Attainment Method – Simplex Method for Goal Programming Problem.

UNIT – IV

Non-Linear Programming - Formulation - constrained optimization - with equaling constraints, with in-equaling constraints - saddle point problems.

UNIT – V

Non-Linear Programming problems Methods - Graphical sign - Kuhn-Tucker conditions with non- negative constrains

TEXT BOOK(S)

1. Kanti Swarup, P.K. Gupta, Man Mohan, Operations Research, Sultan Chand & sons, New Delhi, 2019.
   - UNIT – I Chapter 7
   - UNIT – II Chapter 13 (except Sec 28.7)
   - UNIT – III Chapter 8
   - UNIT – IV Chapter 27
   - UNIT – V Chapter 28 Sec 28.1-28.3

REFERENCE BOOK(S)

1. Hamdy A. Taha, Operations Research (10th Edn.), McGraw Hill Publications, New Delhi.2019.
2. Bazaara, Jarvis and Sherali, Linear Programming and Network Flows, 4th ed., John Wiley, 2010
3. O.L. Mangasarian, Non Linear Programming, McGraw Hill, New York, 1994.
4. Mokther S. Bazaraa and C.M. Shetty, Non Linear Programming, Theory and Algorithms, 3rd edn, Willy, New York, 2013.
5. Prem Kumar Gupta and D.S. Hira, Operations Research: An Introduction, S. Chand and Co., Ltd. New Delhi, 2014.
6. S.S. Rao, Optimization Theory and Applications, 4th edn, Wiley, 2009.
7. G. Hadley, Linear Programming, Narosa Publishing House, 2002

Course Outcomes: At the end of the course, students will be able to

1. Do mathematical formulation of a real life problem into a linear programming problem.
2. Solve linear programming problem using graphical method and simplex

method.
3. Understand Integer programming problem.
4. Find solutions to linear programming problem by dynamic programming.
5. Understand the concepts of nonlinear programming problems.
6. Solve nonlinear programming problems using Wolfe's method and Beale's method.

e-BOOK(S)

1. http://www.ru.ac.bd/stat/wp-content/uploads/sites/25/2019/03/405_01_Srinivasan_Operations-Research_-Principles-and-Applications-Prentice-Hall-of-India-2010.pdf
2. https://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf

Year: I		**Semester:** I

ELECTIVE COURSE I
GRAPH THEORY

Objectives:

1. To give a rigorous study of the basic concepts of Graph Theory.
2. To study the applications of Graph Theory in other disciplines.

***Note*:** Theorems, Propositions and results which are starred are to be omitted.

UNIT – I

Basic Results: Basic Concepts - Subgraphs - Degrees of Vertices - Paths and Connectedness- Operations on Graphs.

UNIT – II

Connectivity: Vertex Cuts and Edge Cuts - Connectivity and Edge - Connectivity, Trees:Definitions, Characterization and Simple Properties - Counting the Number of Spanning Trees - Cayley's Formula.

UNIT – III

Independent Sets and Matchings: Vertex Independent Sets and Vertex Coverings - Edge Independent Sets -Matchings and Factors - Eulerian Graphs - Hamiltonian Graphs.

UNIT – IV

Graph Colourings: Vertex Colouring - Critical Graphs - Triangle - Free Graphs - Edge Colourings of Graphs.

UNIT – V

Planarity: Planar and Nonplanar Graphs - Euler Formula and its Consequences - K5 and K3,3 are Nonplanar Graphs.

TEXT BOOK(S)

1. R. Balakrishnan, K. Ranganathan, A Textbook of Graph Theory, Springer International Edition, New Delhi, 2008.

UNIT I	- Chapter I: 1.1 to 1.4, 1.7
UNIT II	- Chapter III & IV: 3.1, 3.2, 4.1, 4.3 to 4.4
UNIT III	- Chapter V & VI: 5.1 to 5.4, 6.1, 6.2
UNIT IV	- Chapter VII: 7.1 to 7.4
UNIT V	- Chapter VIII: 8.1 to 8.4

REFERENCE BOOK(S)

1. J.A. Bondy, U.S.R. Murty, Graph Theory with Applications, Mac MilanPress Ltd., 1976.
2. Gary Chartrand, Linda Lesniak, Ping Zhang, Graphs and Digraph,CRC press,2010.
3. F.Harary, Graph Theory, Addison - Wesley, Reading, Mass., 1969.

Course Outcomes: At the end of the course, students will be able to

1. Understand and work on the fundamental concepts of graphs.
2. Apply graph theory based tools in solving practical problems.
3. Understand basic concepts in Trees and discuss matching problems and its applications elsewhere.
4. Comprehend and work on the concepts of planarity.

e-BOOK(S)

1. https://www.whitman.edu/mathematics/cgt_online/cgt.pdf
2. https://www.pdfdrive.com/download.pdf?id=188461519&h=0e27445c1a90d11918eeab7108536b09&u=cache&ext=pdf