Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD

CIRCULAR NO.SU/Sci. & Tech./Colleges./NEP/16/2023

It is hereby inform to all concerned that, the syllabi prepared by the Board of Studies & Ad-hoc Boards and recommended by the Dean, Faculty of Science & Technology, the Hon'ble Vice-Chancellor has accepted **the following curriculum of All Post Graduate Degree Courses as per Norms of National Education Policy – 2020 under the Faculty of Science & Technology run to the Affiliated Colleges, Dr.Babasaheb Ambedkar Marathwada University** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

Sr.No.	Syllabi of Affiliated BAMU, Aurangabad.	Semester
1.	M.Sc.Zoology	Ist and IInd Semester
2.	M.Sc.Microbiology	Ist and IInd Semester
3.	M.A/M.Sc.Mathematics	Ist and IInd Semester
4.	M.Sc.Geology	Ist and IInd Semester
5.	M.Sc.Biophysics	Ist and IInd Semester
6.	M.Sc.Bioinformatics	Ist and IInd Semester
7	M.Sc. Information Technology	Ist to IVth Semester
8.	M.Sc.Computer Science	Ist to IVth Semester
9.	M.Sc.Botany	Ist and IInd Semester
10.	M.Sc.Enviornmental Science	Ist and IInd Semester

This is effective from the Academic Year 2023-24 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.
REF.No.SU/NEP/2023/ 8752-60
Date:- 08.08.2023.

★ ★ ★ ★ ★ ★★★★★

Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

1] **The Principal of all concerned affiliated Colleges, Dr. Babasaheb Ambedkar Marathwada University,.**
2] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

1] The Director, Board of Examinations & Evaluation, Dr.BAMU,A'bad.

2] The Section Officer,[M.Sc.Unit] Examination Branch,Dr.BAMU,A'bad.
3] The Programmer [Computer Unit-1] Examinations, Dr.BAMU,A'bad.
4] The Programmer [Computer Unit-2] Examinations, Dr.BAMU,A'bad.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.BAMU,A'bad.
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OK

DR. BABASAHEB AMBEDKAR MARATHWADA

UNIVERSITY, AURANGABAD

FACULTY OF SCIENCE & TECHNOLOGY

2 Years P.G. Programme in Science

(M.A./M.Sc.)

As per National Education Policy-2020

(To be implemented from Academic Year 2023-24)

Course Structure and Curriculum

For Affiliated Colleges/Institutions

(Outcome Based Credit System)

Dr. J. A. Nanaware
Chairman - BoS

Subject: Mathematics

Dean
Faculty of Science & Technology
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad

(Effective from 2023- 2024)

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Preamble

Mathematics is an indispensable tool for science, engineering, and technology. It is the basic language for understanding the world and lends precision to scientific thought. Dr.Babasaheb Ambedkar Marathwada University, has decided to adopt the New Education Policy -2020 as per the directives of the University Grants Commission and Government of Maharashtra from the academic year 2023-2024 for the post-graduate programmes run by affiliated colleges of the Dr.Babasaheb Ambedkar Marathwada University. Taking into consideration the rapid growth in science, engineering, and technology and new approaches in different branches of Mathematics and related subjects, Board of Studies in Mathematics with the concern of teachers of Mathematics from affiliated colleges of this University has prepared the syllabus for M.Sc. Mathematics Program as per (NEP-2020). This course provides training in different aspects of Pure Mathematics, equipping you with a range of mathematical skills in problem-solving, project work and presentation. You have the opportunity to learn advanced core pure mathematics topics together with a range of more specialized options, and undertake an independent research project in your chosen area.

Two-Year Post-graduate Program

Course and Credits Distribution of Two years/One Year PG/Master's Degree Program with Entry & Exit Option

Faculty of Science & Technology

Year / level	Semester	Major subject		RM	OJT /FP	RP	Credits	Degree
		DSC Core Mandatory	DSE (Elective)					
First year 6.0	I	3(4) +2=14	4	4			22	PG Diploma (after 3 years degree)
	II	3(4) +2=14	4		4 Complete during Summer break		22	
Cum. Cr. For PG Diploma		28	08	4	4		44	
Exit option with Post-graduate Diploma (44 credits) after first year or two semester with completion of courses equivalent to 44 credits								
Second Year 6.5	III	3(4)+2=14	4			4	22	PG Degree after 3 years UG or PG Degree after 4 years UG
	IV	3(4)=12	4			6	22	
Cum. Cr. For 1 year PG Degree		26	8			10	44	
Cum. Cr. For 2 years PG Degree		54	16	4	4	10	88	
2 Years -4 sem.PG Degree (88 credits) after three year UG Degree or 1 Year -2 sem. PG Degree (44 credits) after four year UG degree								

Note- DSC-is based on specialization

ABBREVIATION:

Major – Comprising Mandatory –is based on specialization

DSE- Discipline Specific Elective

OJT – On-the- Job Training

FP – Field Project (Corresponding to the Major (Core) Subject)

RP – Research Project (Corresponding to the Major (Core) Subject)

Internship/Apprenticeship - (Corresponding to the Major (Core) Subject)

AS PER NEP 2020

Credit distribution structure for Two Years/One Year Programme with Multiple Entry and Exit options

Effective from AY 2023-2024

Discipline Specific Core in **Mathematics**

Class: M.A./ M.Sc. First Year Semester: Ist Semester Subject: Mathematics

Course type	Course Code	Course Name	Teaching Scheme (Hrs./ week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Major Mandatory DSC	MAT/MJ/500	Abstract Algebra-I	4	-	4	-	14
	MAT/MJ/501	Real Analysis-I	4	-	4	-	
	MAT/MJ/502	Complex Analysis-I	4	-	4	-	
	MAT/MJ/503P	Latex Typesetting –I	-	4	-	2	
DSE (Choose any one from pool of courses)	MAT/DSE/504 OR MAT/DSE/505 OR MAT/DSE/506	Discrete Mathematics-I OR Differential Equations-I OR General Relativity-I	4	-	4	-	4
RM	MAT/RM/507	Research Methodology	4	-	4	-	4
			20	4	20	2	22 credits

Class: M.A./M.Sc. First Year (First Semester) Mathematics

1.DSC:

1. **MAT/MJ/500 :** Abstract Algebra-I

   MAT/MJ/501 : Real Analysis-I

   MAT/MJ/502: Complex Analysis-I

   MAT/MJ/503P : Latex Typesetting-I

2. DSE- 1&2 (T/P): (Choose any one from Pool /Basket)

   MAT/DSE/504: Discrete Mathematics-I

   MAT/DSE/505: Differential Equations-I

   MAT/DSE/506: General Relativity-I

3. **RM:**

   MAT/RM/507: Research Methodology

Class: M.A./M.Sc. First Year Semester: II[nd] Semester Subject: Mathematics

Course type	Course Code	Course Name	Teaching Scheme (Hrs./ week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Major Mandatory DSC	MAT/MJ/550	Abstract Algebra-II	4	-	4	-	14
	MAT/MJ/551	Real Analysis-II	4	-	4	-	
	MAT/MJ/552	Complex Analysis-II	4	-	4	-	
	MAT/MJ/553P	Latex Typesetting-II	-	4	-	2	
DSE (Choose any one from pool of courses)	MAT/DSE/554 OR MAT/DSE/555 OR MAT/DSE/556	Discrete Mathematics-II OR Differential Equations-II OR General Relativity-II	4	-	4	-	4
OJT/FP	MAT/OJT/FP/557	Field Project-I (During Summer Break)	4	-	4	-	4
			20	4	20	2	22 credits

Class: M.A./M.Sc. First Year (Second Semester) Mathematics

1.DSC:

MAT/MJ/550 : Abstract Algebra-II

MAT/MJ/551 : Real Analysis-II

MAT/MJ/552 : Complex Analysis-II

MAT/MJ/553P : Latex Typesetting-II

2.DSE- 3&4 (T/P): (Choose any one from Pool /Basket)

MAT/DSE/554: Discrete Mathematics-II

MAT/DSE/555: Differential Equations-II

MAT/DSE/556: General Relativity-II

3. OJT/FP-1:

MAT/OJT/FP/557: FP-I

Vision and Mission

Vision:

Developing our intellectually vigorous community of students and faculty, together engaging in teaching, learning, and research that advance knowledge in diverse areas of mathematics and support current progress in science and technology.

Mission:

- To discover, mentor and nurture mathematically inclined students and provide them supportive environment that fosters intellectual growth.
- To employ effective educational tools for post-graduate courses.
- To perform widely recognized research in focused ares of mathematical theory, methodology and education.
- To explore applications of mathematics and engage in collaborative research in an interdisciplinary environment.
- To provide professional services based on our diverse mathematical expertise to the scientific, technical and educational community.

Programme Educational Outcomes:

M.Sc. Mathematics is a two-year postgraduate program that deals with a deeper knowledge of advanced mathematics through a vast preference of geometry, calculus, algebra, number theory, dynamical systems, differential equations etc. Banks, universities, share markets, space agencies, research centers, etc., offer good job opportunities for the graduates. Since mathematics has a good job scope worldwide, students get placed in reputed firms.

Program Outcomes:

- To enhance computational skills and Mathematical reasoning among the students.
- To develop the ability to think critically, logically, and analytically.
- To enhance career opportunities in education, research, and industries.
- To develop skills in mathematical softwares.

Program Specific Outcomes:

- To formulate, analyze, and solve problems through application of fundamental mathematical techniques.
- To develop the ability to determine the validity of a given argument, develop mathematical thinking and be able to solve mathematical problems and construct mathematical proofs independently.
- To demonstrate an understanding of the foundations of various branches of mathematics and apply the same to formulate and develop mathematical arguments in a logical manner
- Apply knowledge and mathematical skills to translate information presented into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.
- Investigate and apply mathematical solutions in a variety of contexts related to science, technology, business and industry, and illustrate these solutions using symbolic, numeric, or graphical methods.
- Build a solid foundation for higher studies in mathematics and other disciplines requiring quantitative techniques and enhancing their career prospects through success in competitive examinations for further academic progression or placement in various positions requiring mathematical or quantitative background as a pre-requisite

Eligibility:

The student seeking admission to M.A./M.Sc.Mathematics First Year program shall have passed three year B.A./B.Sc. Mathematics or B.Sc. (Mathematics with Computer Science Applications) or any other relevant degree with Mathematics as the main subject.

The student seeking admission to M.A./M.Sc.Mathematics Second Year program shall have passed four year B.A./B.Sc. Mathematics or B.Sc. (Mathematics with Computer Science Applications) or any other relevant degree with Mathematics as the main subject.

Duration: The M.A. / M.Sc. Degree Course is of two years duration, spread over four semesters.

Medium of Instruction: The medium of instruction shall be English

Attendance:

Every student must have at least 75% attendance in each of the courses (Theory & Practical) in each semester. Shortage of attendance will be dealt with as per the University rules from time to time

Course Code: **MAT/MJ/500** Course Title: **Abstract Algebra-I**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn algebraic structures such as groups, cyclic groups, permutation groups and their properties.
- To understand the concept of isomorphism and its properties.
- To study ideals and irreducible polynomials.

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

CO1: Analyze the algebraic structure

CO2: Apply Caley's theorem and find the external direct products

CO3: Analyse the irreducible polynomial and ideals and fields.

Course Contents:

Unit – I

Groups, Subgroups, Cyclic groups, Properties of cyclic groups, Classification of subgroups of cyclic groups.

Unit – II

Permutation groups, Definition and notations, Cycle notation, Properties of permutations.

Unit – III

Isomorphism, Definition and examples, Cayley's theorem, Properties of isomorphisms, External direct products, Definition and examples, Properties of external direct product, the group of units modulo n as an external direct product.

Unit-IV

Ideals, Sum and direct sum of ideals, maximal and prime ideals, examples of maximal ideals, Nilpotent and Nil ideals, Irreducible polynomials and Einstein criteria, Adjunction of roots, Algebraic extensions, algebraically closed fields.

Text Books:

1. Joseph A. Gallian: Contemporary Abstract Algebra, *Ninth Edition, CENGAGE,* 2020

Scope: **Chapter 2, 3, 4, 5, 6, 8 (up to Theorem 8.3)**

2. **P.B. Bhattacharya, S.K. Jain, S.R. Nagpaul**: **Basic Abstract Algebra**, Second edition, *Cambridge University Press* (Reprint 2018)

   Scope: Chapter 10 (Articles 3, 4, 5), Chapter 15 (1, 2, 3, 4)

References:

1. I.N.Herstein: Topics In Algebra, Wiley Eastern Ltd., New Delhi 1975
2. M.Artin: Algebra, Pretice-Hall of India. 1991
3. D.S.Malik. J.N.Mordenson, and M.K.Sen: Fundamentals of Abstract Algebra. McGraw-Hill International Edition. 1997
4. S.Kumarsen:, Linear Algebra, A Geometric Approach, Prentice- Hall of India. 2000
5. Vivek Sahai and Vikas Bist: Algebra, Narosa Publishing House, 1999.

Course Code: **MAT/MJ/501** Course Title: **Real Analysis-I**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn Riemann Stieltjes integral, fundamental theorem of calculus, pointwise and uniform convergence
- To study theorems on uniform convergence, functions of several variables
- To acquire skill of partial differentiation and Jacobian.

Course Outcomes: After completion of the course, student will be able to:

CO1: Find Riemann Stieltjes integral, test pointwise and uniform convergence.

CO2: Analyze theorems on uniform convergence, power series, Abel's and Taylor theorem and linear transformation.

CO3: Determine the partial derivative and Jacobians of functions of several variables.

Course Contents:

Unit – I

Definition and existence of Riemann-Stieltjes integral, Properties of the integral, Integration and Differentiation, The fundamental theorem of calculus, Examples.

Unit - II

Integration of vector valued functions, Rectifiable curve, Examples, Sequences and series of functions, Point wise and uniform convergence, Cauchy criterion for uniform convergence. Weierstrass M-test, uniform convergence and continuity, uniform convergence and Riemann-Stieltjes integration, Examples.

Unit - III

Uniform convergence and Differential, The Stone – Weierstrass theorem, Examples. Power series, Abel's and Taylor's theorems, Uniqueness theorem for power series. Examples.

Unit - IV

Functions of several variables, Linear transformations, Derivatives in an open subset of R^n, Chain rule, Examples, Partial derivations. Interchange of the order of differentiation, The inverse function theorem, The implicit function theorem, Jacobins, Derivatives of higher order, Differentiation of integrals, Examples.

Text Book: Walter Rudin, Principles of Mathematical Analysis, (3rd Edition) McGraw Hill, Kogakusha 1976.

Articles:6.1 to 6.27, 7.1 to 7.18, 7.26, 7.27, 8.1 to 8.5, 9.1 to 9.21, 9.24 to 9.29, 9.38 to 9.42

Reference Books:

1. T. M. Apostol, Mathematical Analysis, Narosa, New Delhi,1985.
2. J. C. Burkill and H. Burkill, A second course in Mathematical Analysis, Cambridge University Press,1970.
3. S. L. Lang, Analysis- I and II, Addison Wesley,1969.

Course Code: **MAT/MJ/502** Course Title: **Complex Analysis-I**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn complex number system, Branch of logarithm, Roots of unity.
- To study analytic function, Harmonic function, Power series, Taylor series, and Laurent series.
- To determine bilinear transformation, Cross- ratio, trigonometric transformation.

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

CO1: Find the branch of logarithm and roots of unity.
CO2: Analyze analytic function, Harmonic function, Power series, Taylor series and Laurent series.
CO3: Determine convergence of sequence, bilinear transformation, Cross- ratio and perform trigonometric transformation.

Course Contents:

Unit – I: Complex number system, Algebra of complex number, the complex plane, Polar representation, Roots of unity, Polynomials, Transcendental functions such as exponential, trigonometric and hyperbolic functions, Some hyperbolic identities, Branch of logarithm, Branch point and branch line. **(20 Periods)**

Unit – II: Analytic function, Cauchy-Riemann equations in Cartesian and polar form, Harmonic function, Basic properties of harmonic function, Orthogonal System. **(10 Periods)**

Unit – III: Convergence of sequence of function, Convergence of Series of function Uniform convergence, Power Series, Operations on Power Series, Maclaurin's and Taylor's Series. Laurent Series. **(15 Periods)**

Unit – IV: Conformal Mapping, Mapping properties, Bilinear and Conformal transformation, Linear transformation, the point at infinity, Special bilinear transformation, Cross- ratio, Trigonometric transformation. **(15 Periods)**

Reference books:

1. Herb Silverman; Complex variables, Haughton Mifflin Company Bostan, 1975.
2. John.B. Conway; Functions of One complex variables, second edition, Narosa Publising House; 2002.
3. Shanti Narayan and P.K.Mittal ; Theory of Functions of a complex variable; S. Chand and Company Ltd. New Delhi-110055.
4. J.V. Deshpande; Complex Analysis, Tata Mcgraw-Hill 1989.
5. Rurel V. Churchil; ComplexVariables and applications, McGraw-Hill Publishing Company-1990.
6. S.Ponnusamy ; Foundation of Complex Analysis, Second edition, Narosa Publising House; 2008.

Course Code: **MAT/MJ/503P**	Course Title: **Latex Typesetting-I**
Credits: **02**	Contact Hours: 30 **(Clock Hours)**
Max.Marks:50	Periods: 30

Course Objectives:

The purpose of this course is to acquaint students with the latest typesetting skills.

Course Outcomes:

CO1: Typeset mathematical formulas, use nested list, tabular & array environments.

CO2: Create or import graphics.

Course Contents:

Unit-I

Preparing an input file, sentences and paragraphs, the document class, sectioning, display material, running Latex, changing the type style, producing mathematical symbols and mathematical formulae, arrays, delimiters, multiline formulae, putting one thing on other, spacing in math mode.

Unit-II

Defining command and environments, producing and including graphics in a Latex file, figures and other floating bodies, lining it up in columns, table of content, cross-reference, bibliography and citation, making index and glossary, slides, overlays and notes, letters.

Reference Books:

1. Kottwitz, S. LaTeX Beginner's Guide. Packt Publishing Ltd., UK, 2011.

2. Leslie L. A Document Preparation System User's Guide and Reference Manual, AddisonWesley Publishing Company, 2001.

3. Tantau,T.: User Guide to the Beamer Class, http://latex-beamer.sourceforge.net.

4.Oetiker,T.:The Not So Short Introduction to LATEX2E, https://tobi.oetiker.ch/lshort/lshort.pdf.

Course Code: **MAT/DSE/504** Course Title: **Discrete Mathematics-I**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn the concepts of semigroups, monoids, Boolean algebra and lattices.
- To apply the concepts to digital network and switching circuits.

Course Outcomes:

CO1: To learn the mathematical logic.

CO2: Understand the concept of semigroups and monoids.

CO3: Study the different types of lattices.

CO4: Understand the concept of Boolean algebra and apply to digital network and switching circuits.

Course Contents:

Unit-I:

Mathematical logic: Propositions, logical connectives, conditional and biconditionals, well-formed formulas, tautologies, logical equivalences and implications, theory of inference for statement calculus, validity using truth tables, rules of inference, consistency of premises.

Unit-II:

Algebraic systems: Definitions, examples and general properties.Semigroups and Monoids: Definitions and examples, Homomorphism of semigroups and monoids, congruence relation, quotient semigroup and Monoids, subsemigroups and submonoids, direct products, basic homomorphism theorems.

Unit-III:

Partial ordering, partially ordered set (Poset), chain, Hasse diagrams of partially ordered set.

Lattices: lattices as partially ordered sets, principle of duality, some properties of lattices, lattices as algebraic system, sublattices, direct product and homomorphism, Some special lattices: complete lattice, bounded lattice, complemented lattice, distributive lattice and modular lattice.

Unit-IV:

Boolean algebra, Boolean algebra as lattices, various Boolean identities, subalgebra,direct product and homomorphism, join-irreducible elements, atoms and antiatoms, Boolean forms and their equivalence, minterms and maxterms, sum-of-products and product-of-sum canonical forms, values

of Boolean expression, Boolean function, symmetric Boolean expression, design and implementation of digital networks, switching circuits.

Text Books:

1. J. P. Tremblay and R. Manohar: Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Company, 1997.
2. C. L. Liu and D. P. Mohapatra: Elements of Discrete Mathematics, Tata McGraw-Hill Publishing Company Ltd., Third edition 2008.

Reference Book:

1. Kenneth H. Rosen: Discrete Mathematics and its Applications, McGraw-Hill Book Company, Seventh edition.

Course Code: **MAT/DSE/505** Course Title: **Differential Equations-I**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To introduce the nonlinear first order ordinary differential equations, method of successive approximations ,existence and uniqueness theorems.
- To introduce various systems of first order ordinary differential equations.

Course Outcomes:

CO1: Solve first order nonlinear ordinary differential equations.

CO2: Find the solution of Peano's existence theorem and Picard-Lindelof theorem.

CO3: Apply the differential and integral inequalities.

CO4: Solve the linear systems.

Course Contents:

Unit I : Existence, uniqueness and Continuation of solutions: Introduction, Method of successive approximations for the initial value problem $y' = f(x,y)$, $y(x_0)=y_0$, The Lipschitz condition. Peano's existence theorem, maximal and minimal solutions.

Unit II : Continuation of solutions, Existence theorems for system of differential equations: Picard-Lindelof theorem, Peano's existence theorem, Dini's derivatives, differential and inequalities, Gronwall- Reid-Bellman inequality, Kamke's uniqueness theorem.

Unit - III: Linear systems: Introduction, superposition principle, preliminaries and basic results, Properties of linear homogeneous system, Theorems on existence of a fundamental system of solutions of first order linear homogeneous system, Abel-Liouville formula.

Unit - IV Adjoin system, Periodic linear system, Floquet's theorem, Inhomogeneous linear systems, applications.

Text Books:

1. E. A. Codington: An Introduction to Ordinary Differential Equations. Prentice Hall of India Private Limited, New Delhi (2002).
Chapter- 5; Articles 4 and 5.
2. Shair Ahmad and M. Rama Mohana Rao: Ordinary differential EquationsTheory of Ordinary Differential Equations withApplications in Biology and Engineering, Affiliated East-West Press (1999).
Chapter – 1: Article 1.1 to 1.5

Chapter – 2: Article 2.1 to 2.3

Reference Books :

1.Philip Hartman: Ordinary differential Equations, 2nd Edition SIAM, (2002).

2.W. T. Reid: Ordinary Differential Equations, John Wiley, New York, (1971).

3.E. A. Codington and N. Levinson: Theory of Ordinary Differential Equations, McGraw-Hill,New York, (1955).

4.D. Somasundaram: Ordinary differential Equations- A First Course, Narosa Publishing House (2016)

Course Code: **MAT/DSE/506** Course Title: **General Relativity-I**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn the concepts of general relativity.
- To study the concepts of tensor calculus.

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

CO1: Explain the concept of general relativity.

CO2: Apply the tensor calculus to relativity.

CO3: Understand the concept of geodesic and its applications

Course Contents:

Unit I:

Review of the special theory of relativity and the Newtonian theory of gravitation. Distinction between Newtonian space and relativistic space. The conflict between Newtonian Theory of gravitation and special Relativity. Non-Euclidean space time. General Relativity and gravitation, desirable features of gravitational theory.

Unit II:

Principle of equivalence and principle of covariance,Transformation of co-ordinates. Tensor, Algebra of tensors. Symmetric and skew symmetric tensors. Contraction of tensors and quotient law.

Unit III:

Tensor Calculus: Christoffel Symbols, Covariant derivative. Intrinsic derivative. Riemannian Christoffel Curvature tensor and its symmetric properties. Bianchi identities and Einstein tensor. Riemannian metric. Generalized Kronecker delta, alternating symbol and Levi-Civita tensor, Dual tensor. Parallel transport and Lie derivative.

Unit-IV :

Geodesic: i) geodesic as a curve of unchanging direction ii) geodesic as the curve of shortest distance and iii) geodesic through variational principle. The first integral of geodesic and types of geodesics. Geodesic deviation and geodesic deviation equation.

Recommended Book(s):

1. L. N. Katkar: Mathematical Theory of General Relativity. Narosa Publishing House, New Dehli, (2014).
2. J.V. Narlikar: Lectures on General Relativity and Cosmology, The Mac Millan com. (1978).

Reference Books:

1. R. Adler, M. Bazin and M. Schiffer: Introduction to General Relativity, McGraw-Hill Book Com. (1975).
2. M. Carmeli: Classical Fields: General Relativity and Gauge Theory, Wiley-Interscience Publication (1982)
3. J. L. Synge: The General Relativity, North Holland Publishing Com. (1976)

4.L.D. Landau and E.M. Lifshitz: The classical Theory of fields, Pergamon Press. (1980)

5.B.F. Shutz: A first course in General Relativity, Cambridge University Press. (1990).

6. H. Stepheni: General Relativity: An Introduction to the theory of gravitational field. Cambridge University Press. (1982)

Course Code: **MAT/RM/507** Course Title: **Research Methodology**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

1. To define research and describe the research process and research methods
2. To understand qualitative research and methods used to execute and validate qualitative research
3. To know how to apply the basic aspects of the research process in order to plan and execute a research project.
4. To provide insight into the processes that lead to the publishing of research.
5. To be able to present, review and publish scientific articles

Course Outcomes:

Students will be able to -

1. understand and explain research process
2. do systematic literature survey, formulation of a research topic, study design, analysis and interpretation of data.
3. to design a research approach for a specific research issue of their choice.
4. select a suitable analytical method for a specific research approach.
5. demonstrate a good understanding of how to write a research report.
6. critically assess published quantitative research with regard to the statistical methods and approaches adopted
7. create a research document for implementation research project

Course Contents:

Part – 1 (02 credit : 30 Contact Hours)

Unit - I: Research Fundamentals and Identification of Research Problem: (10 Hrs.)

Research Fundamentals

Introduction: Definition, objectives of the research, characteristics of the research, what makes people to do research, importance of research, Qualitative and Quantitative Research: Qualitative research - Quantitative research - Concept of measurement, causality, generalization, and replication. Merging the two approaches.

Identification of Research Problem

Defining the research problem: Identification of research problems, selection of research problem, facts one should know regarding selection of research problem, the process of research problem definition, some facts involved in defining research problem, Research Design: Concept and Importance in Research - Features of a good research design - Exploratory Research Design - concept, types and uses, Descriptive Research Designs -

concept, types and uses. Experimental Design: Concept of Independent & Dependent variables, Case Studies.

Unit - II: Formulation of Research Problem **(10 Hrs.)**

Formulation of the problems: steps involved in defining a problem, formulation of the problems, Formulation of hypothesis: Concept of hypothesis, hypothesis testing, developing the research plan: implementation, interpreting and reporting the findings, Importance of hypothesis in decision making, Case Studies. Interpretation of Data. Measurement: Concept of measurement- what is measured? Problems in measurement in research- Validity and Reliability. Levels of measurement Nominal, Ordinal, Interval, Ratio.

Unit – III : Research Report and Proposal Writing **(10 Hrs.)**

Introduction, research proposal writing: costing, the research proposal, rationale for the study, research objectives, research methodology, target respondents, research Centres, sample size and sample composition, sampling procedures, research project execution, research units; An insight into research report and proposal, research project synopsis, research report writing : types of research reports, guidelines for writing reports; Steps in writing report, report presentation, typing the report, documentation and bibliography, formatting guidelines for writing a good research report / research paper, Paper Writing- Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Case Studies.

Part – II (02 credit : 30 Contact Hours)

Presentations, case studies, Assignments, Tutorials based on Module I to III **(30 Hrs.)**

Students are expected to do the Followings

1 Select Broad topic of Research Project (to be implemented from second semester onwards)
2 Read the Basic concepts / fundaments of broad topic
3Identify 10 SCOPUS / WEB OF SCIENCE Indexed Journals related to broad topic
3. Search and download 20 research articles from above research Journals
4. Do systematic review of above 20 research articles
5. While doing review of each of above mentioned 20 research articles, students are expected prepare notes on following points
   a) What are the objectives of the research article?
   b) What methodology has been adopted?
   c) What are prominent results?
   d) How these results of relevant to the latest development of the subject?
   e) What is novelty of research article?
   f) What are prominent shortcomings of this research a presented in this research article?
   g) What are your plans to address those shortcoming?

6. Draft the fine-tuned title of research project
7. Draft hypothesis
8. Draft Objectives and Methodology
9. Draft expected outcome of the research project

At the end of the assignment, students are expected to prepare a report having following points

i) Fine-tuned title of Research Project
ii) Fundamental aspects of the fine-tuned research topic
iii) Hypothesis
iv) Objectives
v) Methodology
vi) Detailed Experimental plan
vii) Expected outcome
viii) References

References:

1. Research Methodology by Dr. S. L. Gupta, Hitesh Gupta; International Book House Pvt Ltd **(2013),** ISBN-10: 8191064278, ISBN-13: 978-8191064278
2. Basic Research Methods-Gerard Guthrie SAGE Publications, India, Pvt Ltd, New Delhi **(2010),** ISBN-10: 8132104579, ISBN-13: 978-8132104575
3. Research Methodology-methods and techniques By C. R. Kothari, New Age International Publishers **(2011)** ISBN 978-81-224-1522-3
4. Principles of Research Methodology- Phyllis G. Supino, Jeffrey S. Borer; Springer, Verlag New York **(2012),** ISBN-ebook: 1461433592, ISBN (Hardcover): 978-1461433590
5. Research Design Qualitative, Quantitative. and Mixed Methods Approaches- John W. Creswell; SAGE Publications Ltd, UK **(2011),** ISBN-9780857023452
6. Research Methodology -A Step-by-Step Guide for Beginners- Ranjit Kumar; Sage Publications Ltd**(2010)**, ISBN- 1849203016.
7. Scientific Writing and Communication- Angelika Hofmann; Oxford University Press, US **(2010),** ISBN-13-: 978-0 199947560, ISBN-10: 01 99947562
8. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded-Joshua Schimel, Oxford University Press, **(2011)**, ISBN: 9780199760237
9. Handbook of Scientific Proposal Writing- A.YavuzOruc; CRC Press, Taylor & Francis group **(2011)**, ISBN: 9781439869185

Curriculum: M.A./M.Sc.Mathematics (First Year) Semester-II

Course Code: **MAT/MJ/550** Course Title: **Abstract Algebra-II**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn vector spaces and linear transformation and their properties.
- To understand dual space, eigen value and eigen vectors and its properties.
- To study Gram-Schmidt orthogonalization process.

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

CO1: Explain the properties of vector spaces and linear transformations.

CO2: Determine eigen values and eigen vetors.

CO3: Analyse and apply the Gram-Schmidt orthogonalization process

Course Contents:

Unit - I: Vector Spaces, subspaces, linear combinations and system of linear equation, linear dependence and independence, Bases and dimension maximal linearly independent subsets.

Unit -II: Linear Transformation, Null spaces, Ranges, the matrix representations of linear transformation, composition of linear transformation and matrix multiplication,Invertibility and isomorphisms, the change of coordinate matrix, dual spaces

Unit-III: Homogenous linear differential equation with constant coefficient,Eigen values and Eigen vectors, Diagonalizability, Invariant subspaces and the Caley-Hamilton theorem.

Unit-IV: Inner product and norms, The Gram-Schmidt orthogonalization process and orthogonal complements, the adjoint of a linear operator, Bilinear and quadratic forms, Jordan Canonical form I, Jordan Canonical Form II.

Textbook:

Stephen S.H. Friedberg, Arnold J. Insel, Lawrence E. Spence: Linear Algebra, Prentice- Hall International, 4th edition.

Scope:

Chapter1: Article 1.2 to 1.7

Chapter 2: Article 2.1 to 2.7

Chapter 5: 5.1, 5.2, 5.4

Chapter 6: 6.1 to 6.3, 6.8

Chapter 7: 7.1, 7.2

Reference Books:

1 I.N.Herstein: Topics In Algebra, Wiley Eastern Ltd., New Delhi 1975
2 D.S.Malik. J.N.Mordenson, and M.K.Sen: Fundamentals of Abstract Algebra. McGraw-Hill International Edition. 1997
3 S.Kumarsen:, Linear Algebra, A Geometric Approach, PHI. 2000
4 VivekSahai and VikasBist: Linear Algebra, Narosa Publishing House, 1999
5 V.Krishnamurthy et. Al., An Introduction to Linear Algebra, Affiliated East West Press, New Delhi, 2003

Course Code: **MAT/MJ/551** Course Title: **Real Analysis-II**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn notion of measure and measurable spaces
- To understand Riemann and Lebegue integration.
- To study some inequalities.

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

CO1: Understand measurable spaces and its properties.

CO2: Determine Lebegue integrations.

CO3: Analyse and apply some inequalities.

Course Contents:

Unit - I Measure on the real line. Lebegue outer measure, measurable sets. Regularity. Measurable functions. Boral and Lebegue measurability. Examples.

Unit - II Integration of functions of a Real variable. Integration of a simple function. Integration of non- negative functions. The general integral. Integration of series. Examples.

Unit - III Riemann and Lebeque Integrals, Differentiation. The four derivates, Functions of bounded variations. Lebegue's differentiation theorem, Examples, Abstract Measure spaces.

Unit - IV Measures and outer measures, Extension of a measure, Uniqueness of the extension. Completion of a measure spaces, Integration with respective to a measure, Examples,The L^p spaces, Convex functions. Jensen's inequality, The inequalities of Holder and Minkowski Completeness of L^p Convergence in measure, Almost uniform convergence,Examples

Text Book:

G. de Barra: Measure Theory and Integration. Wiley Eastern Ltd. 1981. Reprint 2003.

Scope:

Articles: 2.1-2.5, 3.1 – 3.4, 4.1, 4.3 - 4.5, 5.1 – 5.6, 6.1 – 6.5, 7.1 and7.2

Reference Books:

1. P. K. Jain and P. V. Gupta, Lebesgue Measure and Integration, New Age International (P) Ltd. Publication New Delhi. 1986 (Reprint2000)
2. P. R. Halmos, Measure Theory, Von No strand, Princeton 1950
3. R. G. Bartle, The elements of Integration, John Wiley, New York1966.
4. I. K Rana, An Introduction to measure and Integration, Narosa, Delhi 1997.

Course Code: **MAT/MJ/552** Course Title: **Complex Analysis-II**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn complex integration, Jordan curve, Cauchy's theorem, Cauchy's integral formula, Morera's theorem and Liouville's theorem.
- To study maximum modulus principle and open mapping theorem.
- To determine the singularities and residue.
- To learn meromorphic functions, infinite Products and gamma function

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

CO1: Find and apply the complex integration, Jordan curve, Cauchy's theorem, Cauchy's integral formula, Morera's theorem, Liouville's theorem,
CO2: Explain the maximum modulus principle, open mapping theorem.
CO3: Determine the singularities and residue.
CO4: Define and identify meromorphic functions, infinite products and gamma function.

Course Contents:

Unit – I: Complex integration, curves, Jordan curve, Parametrization, Line integrals, Cauchy's weak' theorem, Cauchy's theorem, Applications of Cauchy's theorem, Cauchy's integral formula, Morera's theorem, Cauchy's inequality, Liouville's theorem, Fundamental theorem of algebra. **(20 Periods)**

Unit – II Maximum modulus theorem, Gauss's Mean Value theorem, Maximum modulus principle, Schwarz's lemma, Argument principle, Rouche's theorem, Hurwitz's theorem, Open mapping theorem . **(15 Periods)**

Unit – III: Singularities, classification of singularities, Riemann's theorem, Casorati-Weierstrass theorem, Residue, Residue theorem, Method of finding residue. **(10 Periods)**

Unit – IV: Entire and Meromorphic Functions, Infinite Products, Weierstrass's theorem,Mittag-Leffler's theorem. Gamma function, Properties of Gamma function, Gauss's formula,Functional equation. **(15 Periods)**

Reference books:

1. Herb Silverman; Complex variables, Haughton Mifflin Company Bostan, 1975.
2. John.B. Conway; Functions of one complex variables, Second edition , Narosa Publising House; 2002.
3. Shanti Narayan and P.K.Mittal ; Theory of Functions of a complex variable; S. Chand and Company Ltd. New Delhi-110055.
4. Rurel V. Churchil; ComplexVariables and applications, McGraw-Hill Publishing Company-1990.

Course Code: **MAT/MJ/553P** Course Title: **Latex Typesetting-II**

Credits: **02** Contact Hours: 30 **(Clock Hours)**

Max.Marks:50 Periods: 30

Course Objectives:

The purpose of this course is to build the skill of preparation of beamer presentation and article/book chapter.

Course Outcomes: Upon successful completion of this course sdent will be able to

CO1: Prepare document class and typesetting environment

CO2: Make presentation and article.

Course Contents:

Unit-I : Design it yourself: document class, page style, title page, customizing the style, line and page breaking, numbering, length, spaces and boxes, formatting with boxes, centring and flushing, list making environments, changing font type size and special symbols, picture, picture environments, picture objects, text, boxes, straight lines, arrow, stacks, circles, oval, framing, curve, grid, repeat patterns.

Unit-II : Making presentation slides in beamer class LaTeX, various styles in beamer presentation, dynamic slides. PostScript macros for Generic TeX (PsTrix): arguments, dimension, coordinates, angles, line styles, fill styles, custom styles, custom graphics, picture tools, text tricks, node and connection special tricks. Basics of MathJax, Mathjax configuration options.

Reference Books:

1. Kottwitz, S. LaTeX Beginner's Guide. Packt Publishing Ltd., UK, 2011.

2. Leslie L. A Document Preparation System User's Guide and Reference Manual, AddisonWesley Publishing Company, 2001.

3. Tantau,T.: User Guide to the Beamer Class, http://latex-beamer.sourceforge.net.

4.Oetiker,T.:The Not So Short Introduction to LATEX2E, https://tobi.oetiker.ch/lshort/lshort.pdf.

Course Code: **MAT/DSE/554** Course Title: **Discrete Mathematics-II**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To learn the graphs and types of graphs, Euler's and Hamiltonian graphs.
- To study trees, minimum spanning trees and some results.

Course Outcomes: After successful completion of the course student will be able to

CO1: Study the basic concepts of graph theory and matrix representation of graphs.

CO2: Explain paths, circuits and connectedness of graphs.

CO3: Study the Euler's formula for connected planar graphs and Kuratowski's theorem.

CO4: Understand properties of trees, cut sets and minimum spanning trees.

Course Contents:

Unit-I:

Graphs: Directed and undirected graphs, basics definitions, subgraphs, complement of a subgraph, isomorphism of two graphs, degree of vertex, outdegree and indegree of digraph, digraph and relations, representation of graphs, incidence matrix and adjacency matrix.

Unit-II:

Paths, circuits, reachability and connectedness, unilaterally connected and strongly connected graphs, shortest paths in weighted graphs, Eulerian paths and circuits, Euler's theorems on the existence of Eulerian paths and circuits.

Unit-III:

Hamiltonian paths and circuits, sufficient condition for existence of Hamiltonian path in an undirected graph (statement only), planer graphs, and Euler's formula for connected planar graphs, Kuratowski's theorem (statement only).

Unit-IV:

Trees, rooted trees, spanning trees, cut sets, fundamental cut sets and fundamental circuits, minimum spanning trees, Kruskal's algorithm and Prim's algorithm for finding minimum spanning tree.

Text Books:

1. C. L. Liu and D. P. Mohapatra: Elements of Discrete Mathematics, Tata McGraw-Hill Publishing Company Ltd., Third edition 2008.

2. J. P. Tremblay and R. Manohar: Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Company, 1997.

Reference Book:

Narsingh Deo: Graph Theory with Applications to Engineering and Computer Science, Printice-Hall of India Pvt. LTD. New Delhi, 2010.

Course Code: **MAT/DSE/555** Course Title: **Differential Equations-II**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To introduce concept of general second and higher order ordinary differential equations and its transformations.
- To study Sturm's comparison theorems, Sturm-Liouville boundary value problems, oscillatory and non-oscillatory properties of solution.

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

CO1: Explain the second and higher order ordinary differential equations.

CO2:Familiar with Sturm's comparison theorems,

CO3:Find the solution of Sturm-Liouville boundary value problems.

CO4:Find the ocillatory solution of the differential equation.

Course Contents:

Unit - I : Preliminaries, Basic Facts: Superposition principles, Lagrange Identity, Green'sformula, variation of constants, Liouville substitution, Riccati equations,Prefer Transformation.

Unit - II : Theorems of Strum; Sturm's first comparison theorem, Sturm's separation theorem.

Unit - III : Sturm-Liouville boundary Value Problems: definition, eigenvalues, eigenfunctions, orthogonality.

Unit - IV: Number of zeros, Non oscillatory equations and principal solutions, Nonoscillation theorems.

Text Books:1. Philip Hartman: Ordinary differential Equations, 2nd Edition SIAM, 2002.

Chapter – XI: Article 1 to 7. Chapter – 4 – article 8 only.

Reference Books:

1. W. T. Reid: Ordinary Differential Equations, John Wiley N.Y. (1971).
2. E. A. Coddington and N. Levinson: Theory of Ordinary differential Equation, McGraw-Hill, New York, (1955).
3. S.G.Deo and V.Raghavendra , Ordinary Differential Equations and Stability Theory, Tata McGraw-Hill Publishing Company Limited, New Delhi (1990).

Course Code: **MAT/DSE/556** Course Title: **General Relativity-II**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives:

- To understand isometry and Einstein space.
- To study fundamentals of space time.
- To learn Kepler's laws.

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

CO1: Define isometry and Einstein space

CO2: Analyze space time and conservation laws.

CO3: Understand Einsteins field equations and Kepler's laws.

Course Contents:

Unit I: Killing vector fields. Isometry. Necessary and sufficient conditions for isometry. Integrability condition, Homogeneity and isometry. Maximally symmetric space-time. Einstein space.

Unit II: The action principle, Einstein's field equations from action principle and its Newtonian approximation. Poisson's Equation as an approximation of Einstein's Field equations. Flat spacetime and empty space-time. Local conservation laws associated with perfect fluid distribution, the energy momentum tensor.

Unit-III: The stress-energy momentum tensor for perfect fluid, electromagnetic field. Schwarzschild space-time. Spherical symmetry. Einstein field equations under spherical symmetry. Schwarzschild exterior solution.

Unit IV: Planetary orbits and Kepler's laws, Relativistic analogues of Kepler's laws. Three crucial tests for general Theory of relativity: 1. Perihelion of the planet Mercury, 2. Bending of light, 3. Gravitational red shift. Isotropic co-ordinates. Retarded time. Isotropic form of Schwarzschild exterior solution.

Recommended Text Book(s):

1 L. N. Katkar: Mathematical Theory of General Relativity. Narosa Publishing House, New Dehli, (2014).

2.J.V. Narlikar: Lectures on General Relativity and Cosmology, The Mac Millan com. (1978).

Reference Books:

1. R. Adler, M. Bazin and M. Schiffer: Introduction to General Relativity, McGraw-Hill Book Com. (1975).

2.M. Carmeli: Classical Fields: General Relativity and Gauge Theory, Wiley-Interscience Publication (1982)

3 . J. L. Synge: The General Relativity, North Holland Publishing Com. (1976)

4.L.D. Landau and E.M. Lifshitz: The classical Theory of fields, Pergamon Press. (1980)

5.B.F. Shutz: A first course in General Relativity, Cambridge University Press. (1990).

6. H. Stepheni: General Relativity: An Introduction to the theory of gravitational field. Cambridge University Press. (1982)

Course Code: **MAT/OJT/FP/557** Course Title: **Field Project-I**

Credits: **04** Contact Hours: 60 **(Clock Hours)**

Max.Marks:100 Periods: 60

Course Objectives: This course provides an opportunity to the students to apply the knowledge acquired in theory courses to the society/industry.

Course Outcomes: After completion of the OJT/FP course, student will be able to:

CO1: Apply the skill/knowledge to real world applications.

CO2: Find and design the related mathematical models

Course Contents:

- Each student shall be given on-job training/ field project based on survey/ data collection on the topic of project assigned to the students.
- Each student shall collect/ conduct the data/survey or search the applications on content learnt in the discipline specific/ elective courses and prepare a detailed report and submit it to the concerned teacher at the end of the semester.

Note: Department/college concerned shall make collaborations/MOUs with industry/ research institutes / NGOs etc. for On Job training /field project.

Note- 1. The workload relating to a course is measured in terms of credits hours.

2. A credit is a unit by which the coursework is measured
3. Each course may have –
   a. only lectures-
   b. lecture and tutorial –
   c. lecture and practicum
   d. lecture, tutorial and practice components
4. One credit- one clock hour lecture in a week
5. Four credits lecture course in a semester means four one-hour lectures per week.
6. In semester of 15 weeks duration = Four credit lecture course is equivalent to 60 hours of teaching in a semester
7. One credit for tutorial means one hour of engagement per week.
   In a semester 15 weeks duration – a one credit tutorial in a course is equivalent to 15 hours engagement
8. A one credit course for- practical/lab work/ community enjoyment program/filed work /seminar/internship /project in a semester means two-hour engagement per week.
9. In a semester of 15 weeks duration a one credit practical in course is equivalent to 30 hours.
10. 1 Credits =25 Marks
