Proposed Syllabus for P.G.

SUBJECT: MATHEMATICS

Syllabus Developed/Proposed by				
S.No.	**Name of Expert/BoS Member**	**Designation**	**Department**	**College/ University**
1.	**Prof. H. S. Shukla**	Retd. Professor&Expert	Mathematics & Statistics	D.D.U. Gorakhpur University, Gorakhpur
2.	**Prof. D.N. Dubey**	Retd. Professor &Expert	Mathematics & Statistics	D.D.U. Gorakhpur University, Gorakhpur
3.	**Prof. J. P. Vishwakarma**	Retd. Professor &Expert	Mathematics & Statistics	D.D.U. Gorakhpur University, Gorakhpur
4.	**Prof. Veena Singh**	Professor& Convener	Mathematics	M.L.K.(P.G.) College, Balrampur
5.	**Prof. Prakriti Rai**	Professor& member	Mathematics	Siddharth University, Kapilvastu, Siddharthnagar
6.	**Dr. Jitendra Kr.Singh**	Associate Professor& member	Mathematics	Siddharth University, Kapilvastu, Siddharthnagar
7.	**Dr. Vijay Kr. Shukla**	Assistant Professor& member	Mathematics	Shivharsh Kisan P.G. College, Basti
8.	**Dr.Triloki Nath**	Assistant Professor& member	Mathematics	Shivharsh Kisan P.G. College, Basti

M.A./M.Sc.I, Semester-I

S. No.	**Course Code**	**Credit/ Marks**	**Name of the Course**	**Remark**
1.	MMHC-401	4/100	Groups and Canonical Forms	Core paper
2.	MMHC-402	4/100	Topology-I	Core paper
3.	MMHC-403	4/100	Differential and Integral Equations	Core paper
4.	MMHC-404	4/100	Hydrodynamics	Core paper
5.	MMHL-405	4/100	Programming in C	Practical
6.	MMHM-406	4/100	Probability and Statistics	Minor Elective
7.	MMHP-407	4	Research Project	Project
Total		28/600		

M.A./M.Sc.I, Semester-II

S.No.	Course Code	Credits/ Marks	Name of the Course	Remark
1.	MMHC-411	4/100	Fields and modules	Core paper
2.	MMHC-412	4/100	Topology-II	Core paper
3.	MMHC-413	4/100	Partial Differential Equations	Core paper
4.	MMHC-414	4/100	Advanced Real Analysis	Core paper
5.	MMHL-415	4/100	Numerical methods with programming in C	Practical
6.	MMHP-416	4/100	Research Project/ Dissertation	Project
Total		24/600		

M.A./M.Sc. II, Semester-III

S. No.	Course Code	Credits/ Marks	Name of the Course	Remark
1.	MMHC-501	4/100	Advanced Complex Analysis	Core paper
2.	MMHC-502	4/100	Banach Spaces	Core paper
3.	MMHE-503	4/100	a. Analytical Dynamics b. Fourier Analysis c. Cryptography d. Riemannian Geometry e. General Relativity f. Machine Learning g. Mathematical Statistics	Elective paper
4.	MMHE-504	4/100	a. Fluid Dynamics b. Computational Methods for Partial Differential Equations c. Bio-Mathematics d. Differential Geometry of manifolds e. Spherical Astronomy-I f. Special Functions-I g. Fuzzy Sets	Elective paper
5.	MMHL-505	4/100	Programming in Python-I	Practical
6.	MMHP-506	4	Research Project	Project
Total		24/500		

M.A./M.Sc.II, Semester-IV

S.No.	Course Code	Credits/ Marks	Name of the Course	Remark
1.	MMHC-511	4/100	Lebesgue Integration Theory	Core paper
2.	MMHC-512	4/100	Hilbert Spaces	Core paper
3.	MMHE-513	4/100	a. Continuum Mechanics b. Theory of Summability c. Operations Research d. Finsler Geometry e. Cosmology f. Applications of Mathematics in Finance g. History of Mathematics	Elective paper
4.	MMHE-514	4/100	a. Magnetohydrodynamics b. Wavelet Theory c. Advanced Mathematical Modelling d. Structure on Differentiable Manifolds e. Spherical Astronomy-I f. Special Functions-II g. Fuzzy logic	Elective paper
5.	MMHL-515	4/100	Programmingin Python-II	Practical
6.	MMHP-516	4/100	Research Project/Dissertation	Project
Total		24/600		

Subject Prerequisites:
Mathematics in U.G. course as a major subject, studied in 6 semesters.

Program Outcomes (POs)

PO1: Inculcate critical and logical thinking to carry out scientific investigation objectively, without being biased with preconceived notions.
PO2: Prepare students for pursuing research or careers in industry, in Mathematical Sciences and allied fields.
PO3: Continue to acquire relevant knowledge and skills appropriate to professional activities.
PO4: Scientific temper in general and mathematical temper in particular will be developed in students.

Program Specific Outcomes (PSOs)

PSO1: The studentswill be able to solve complex problems by critical understanding, logical thinking and analysis.
PSO2:The students will have advanced knowledge on topics in pure mathematics, empowering the students to pursue higher degrees at reputed academic institutions.
PSO3: The students will have a systematic understanding of the concepts, theories of mathematics and their applications in the real world, to an advanced level and so will have enhanced career prospects in a huge array of fields.
PSO4:The students will become employable; they will be eligible for career opportunities in DRDO, ISRO, Defence services, Civil services, Banking Services etc.
PSO5:The students will be able to qualify competitive exams, e.g., NET, GATE, etc.

M.A./M.Sc. I (SEMESTER-I), PAPER-I

GROUPS AND CANONICAL FORMS

Course Code: MMHC-401	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** **GROUPS AND CANONICAL FORMS**	

Course objective: One of the most amazing achievements of twentieth-century mathematics has been the recognition of the abstract approach. This approach has given rise to a large number of new concepts and problems. It has helped us in providing very simple new proofs to many long-standing classical problems. This course introduces the basic concepts of modern algebra. The philosophy of this course is that modern algebraic notions play a fundamental role in mathematics itself and in applicationsto areas such as Physics, Computer Science and engineering.

Unit	Topics	No. of Lectures
I	Fundamentaltheorems on isomorphism of groups, Maximal subgroups. Composition series,Jordan−Holdertheorem, Solvablegroups.	15
II	Nilpotentgroups, The externalandinternaldirectproductof groups, Cauchy'stheoremfor the finitegroup, Sylow's theorems and their applications.	15
III	Recapitulation of linear transformation and their representation as matrices,Similarity of linear transformations, Invariant subspaces, Reduction to triangular forms.	15
IV	Nilpotent transformations, Index of nilpotency, Invariants of a nilpotent transformation, The primary decomposition theorem, Jordan blocks and Jordan forms.	15

Course outcomes:

CO1: The students will be able to constructcomposition series for any group and able to verify Jordan- Holder Theorem.

CO2: Thestudents will be able to define solvable group, nilpotent group.

CO3: The students will be able to see applications of Cauchy's theorem and Sylow's theorems.

CO4: The students will be able to define nilpotent transformations, discuss canonical forms Jordan forms and Jordan blocks.

CO5: The student is equipped with standard concepts and tools at advance level that will serve him/her well towards pursuing research in algebra.

Suggested Readings:

1. I.N. Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. P.B.Bhattacharya,S.K.JainandS.R.Nagpaul:BasicAbstractAlgebra(Second Edition),CambridgeUniversityPress,IndianEdition,1997.
3. SurjeetSinghandQaziZameeruddin:ModernAlgebra,VikasPublishingHouse.Pvt.Ltd.,2005.

4. K.B.Datta:MatrixandLinearAlgebra,PrenticeHallofIndiaPvt.Ltd.,NewDelhi, 2000.
5. S.Kumaresan:LinearAlgebra,AGeometricApproach,PrenticeHallofIndia,2000.
6. S.K.Jain,A.GunawardenaandP.B.Bhattacharya:BasicLinearAlgebrawith MATLAB,KeyCollegePublishing(Springer−Verlag),2001.
7. A.R.Vasishtha&A.K.Vasishtha:ModernAlgebra,KrishnaPrakashanMedia(P) Ltd., Meerut.
8. Luther, I.S. and I.B.S. Passi, Algebra Volumes I and II, Narosa Publishing House, New Delhi 1999.

M.A./M.Sc. I (SEMESTER-I) PAPER-II

TOPOLOGY-I

Course Code: MMHC-402	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: TOPOLOGY-I**	

Course Objectives: Analysis is the life line of Modern Mathematics. General topology serves as a key tool to make an in-depth study of the same. It is a language for communicating ideas of continuous geometry. This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics. It provides us useful tools for studying local properties of a space. The course developed here is intended to give students an insight into various concepts involved in analysis and to make them aware as to how they are acting and reacting in the presence of various topological properties.

Unit	**Topics**	**No. of Lectures**
	Topology, Examples include usual topology, ray, lowerlimit and upper limit topologies on $\mathbb{R}$, the topology of metric spaces, co-finite and co-countable topologies, weak and strongtopologies, Closedsets, the interiorofaset,closureofaset.Characterizationoftopologiesintermso fclosedsets.	15
	Interioroperators,closureaxioms,Neighbourhoods,neighbourhoodsystemandneighbourhoodbase, Topologythroughneighbourhood axioms. Adherentpoints,limitandderivedset,denseset, Baseandsubbasefortopologyandcharacterizationoftopologyintermsofbaseandsubbase axioms.Topology generatedbyafamilyofsubsets.	15
	Continuousfunctionsandtheirproperties.Continuityintermsofopensets,closedsets,neighbourhoods, closures. Convergence of a sequence, sequential continuity, homeomorphisms, Topological invariantproperties, Firstcountableandsecondcountable spaces, Relativetopologyand subspaces,hereditary property,Lindeloftheoremandseparablespaces.	15

	Compactsets and their properties, Finite intersection property, Bolzano-Weierstrass property,Continuousfunctionsandcompactness,Sequentialcompactness,countablecompactness,andtheircomparison.Onepoint compactification.	15

Course outcomes:

CO1: The students are able to understand various concepts like: homeomorphisms, compactness. **CO2:** It provides the students useful tools for studying local properties of a space. **CO3:** The students are able to analyze and link the topics like Algebraic Topology, Functional Analysis,Different types of Integration Theories and many more.**CO4:**The students are able to apply the concepts in Analysis or Algebraic Topology.

Suggested Readings:

1. R. Munkres, Topology, A First Course, Pearson., N. Delhi, 2000.
2. W. J. Pervin, Foundation of General Topology, Academic Press Inc., New York, 1964.
3. J. L. Kelley, General Topology, D Van Nostrand Reinhold Co. New York 1955 (Reprinted by Springer Verlag, New York).
4. K D Joshi, Introduction to General Topology, New Age International (P) Ltd, 1983.
5. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by PHI).
6. N. Bourbaki, Topology I and II, Springer Verlag, New Delhi.
7. S. Willard, General Topology**,** Addison-Wesley, Reading, 1970. Reprinted by Dover. 8.
8. L. A. Steen and J. A.Seebach, Counter Examples in Topology, Holt, Reinhart and Winston, Inc. New York, 1970.

M.A./M.Sc. I (SEMESTER-I), PAPER-III

DIFFERENTIAL AND INTEGRAL EQUATIONS

Course Code: MMHC-403	**Credits-4** **Marks: 25+75**	**Cor**
Total No. of Lectures-Tutorials (in hours per week): 4-1	**Course Title: DIFFERENTIAL AND INTEGRAL**	

Course Objectives: Differential form an important branch of Mathematics and occupy a central position from development extend in many directions along with the applications in physical and engineering sciences. numerous applications in real life physical problems. The purpose of this course is to provide the students easie solving various ordinary differential equations and boundary value problems.

Unit	Topics
I	**Linear Differential Equationsof second of higher order withConstant and Variable Coefficients** toHomogeneous and non-homogeneous linear differential equations,Lineardependence and independence Wronskian, Abel-Liouville formula,Method of undetermined coefficients, Reduction of the order, **Systems of differential equations of first order:**Introduction, differential equations equivalent to a sy

	order equations,vector-matrix method (eigenvalue method) for solvingfirst order linear homogeneous s constant coefficients.
II	**Existence and uniqueness for differential equations of first order:**Initial value problem, Boundary va Picard's iteration method, Lipschitz condition, Existence and uniqueness theorem. **Boundary value Problems and Sturm-Liouville's Theory:** An orthogonal set of functions, Stru Boundary value problem,Green's functions.
III	**Integral Equations: Volterra integral equation and its solution:** Volterra integral equations of first and L_{2-} kernels and functions, Solution by successiveapproximation andsuccessive substitution toa Vo equation.
IV	**Fredholm integral equations and its solution:** Fredholmintegralequati bysuccessiveapproximation,Neumannseries.Pincherle−Goursatkernels(degeneratekernels),Hilbert−Schn symmetrickernels.

Course outcomes:

CO1: The students will be able to apply the techniques for solving ordinary differential equations.

CO2: The students will be able to apply the methods learnt in this course, to calculate, compare and interpret the r disciplines and determine whether the solutions are reasonable.

CO3: The students will be able todesign and develop viable opportunities for correlating the solutions of ordinar to different physical problems.

CO4: Towards the end, students will be able to evaluate and assess the results of various problems in other s concepts.

CO5: The students will be able to determine the solution of Volterra integral equation.

CO6: The students will be able to learn the conversion of integral equation to differential equation and vice-versa.

Suggested Readings:

1. E.A. Coddington, Introduction to ordinary differential equations,Prentice-Hall of India, New Delhi: 2
2. Martha L. Abell, James P. Braselton, Introductory Differential Equations with Boundary Value Proble Elsevier , USA, 2014.
3. S.L. Ross, Differential equations,Third Edition John Wiley and Sons Inc., New York,
4. Boyce, W.E., Diprima, R.C., Elementary differential equations and boundary value problems, John W New York, 7th edition, 1986.
5. TynMyint U, Ordinary Differential Equations., Elsevier North-Holland, 1978
6. F. G. Tricomi, Integral Equations, Dover Publications Inc.
7. R.P. Kanwal: Linear integral equations theory and techniques, Academic Press, New York, (1971).
8. M. Krasnov, A. Kiselev, G. Makarenko, Problems and Exercises in Integral Equations (1971).

M.A./M.Sc. I (SEMESTER-I), PAPER-IV

HYDRODYNAMICS

Course Code: MMHC-404	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures-Tutorials (in hours per week): 4	**Course Title:** HYDRODYNAMICS	

Course objective: The objective of this course is to provide a treatment of topics in Hydrodynamics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems. The objective is to provide the student with knowledge of the fundamentals of Hydrodynamics and an appreciation of their application to real world problems.

Unit	Topics	No. of Lectures
I	Lagrangian and Eulerian methods to describe the fluid motion, Equation of continuity, Boundary conditions, Stream Lines. Pathlines and streak lines, Velocity potential. Irrotational and rotational motions.	15
II	Euler's equations of motion,Pressureequation,Bernoulli'stheorem,Impulsive actions,Flow andcirculation,The permanence ofirrotational motion.Stream function. Irrotational motion in two dimensions. Complex velocity potential. Sources, sinks, doublets, and theirimages.	15
III	The two-dimensional irrotationalmotion is produced by the motion of circular and elliptic cylinders in aliquid, Kinetic energy of liquid, Milne–Thomson circle theorem. The theorem of Blasius,Stoke's stream function.	15
IV	The motion of aspherethroughaliquid.Vortexmotion.Vortexlines.Kelvin'sproofofpermanence.Motionduetocircularandrectilinearvortices.	15

Course outcomes:

CO1: The students will be able to identify the fundamental concepts of Hydrodynamics and their role in modern mathematics and applied contexts.

CO2: The students will be able to apply the Hydrodynamics concepts to diverse situations in Physics, engineering, and other mathematical contexts.

Suggested Readings:

1. B.G.Verma:Hydrodynamics,PragatiPrakashan,Meerut,1995.
2. W.H.BesaintandA.S.Ramsey:ATreatiseonHydrodynamics,PartII,C.B.S.Publishers,Delhi,1988.
3. F.Chorlton:TextBookofFluidDynamics,C.B.S.Publishers,Delhi,1985.

M.A./M.Sc. I (SEMESTER-I), PAPER-V

PROGRAMMING IN C

Course Code: MMHL-405	**Credits-4**	**Practical**

	Marks: 25+75	
Total No. of Lectures/Practicals (in hours per week):8	**Course Title: PROGRAMMING IN C**	

Course objective: The objective of this course is to familiarize the students with problem solving through C- programming. The course aims to give exposure to basic concepts of the C-programming. The lab component of this course is designed to provide hands-on-training with the concepts.

OverviewofC, Constants,Variables,andDataType. Operators, DecisionMakingandBranching, Looping, Multi−dimensionalArrays, Pointers.

Practical:
ProgramminginC(withANSIfeatures)

1. Program to accept three integers and print the largest among them.
2. Program to calculate factorial of a number.
3. Program to print Fibonacci numbers.
4. Program toprinttheprimenumbersbetween1and100.
5. Program to findthesumoffirst10 natural numbers.
6. Program tofindtheaverageofnnumbers.
7. Program tofindtheareaofatrianglewhencoordinatesofitsverticesaregiven.
8. Program tofindtheareaofatrianglewhenlengthsofitssidesaregiven.
9. Program tofindtherootsofaquadraticequation.
10. Program toaddanytwo3x3matrices.
11. Program tomultiplyanytwo3x3matrices.
12. Program to find the transpose of a matrix.
13. Program tosortalltheelementsofa4x4matrix.
14. Program tofindthevalueof the determinantofa5x5matrix.
15. Program toimplement the bisectionmethod.
16. Program to implementfalse−positionmethod.

Course outcomes:
CO1: The students will be able understand arithmetical and functional hierarchical code organization.
CO2: The students will be able to define and manage various type of data and data- structures based on problems subject domain.
CO3: The students will be able to have ability to work with textual information, characters, strings and arrays.
CO4: The students will be able to have ability to handle possible errors during program execution.
CO5:The students will be able to define various types of functions and able to apply various types of decision making, statements/loops.
CO6:The students will be able to able to apply in various fields of Mathematics.

Suggested Readings:

1. E. Balagurusamy: Programming in ANSI C, MacGraw Hill Education (India) Pvt. Ltd., New Delhi.

Note: Each student of Mathematics has to select a Minor-elective paper (Paper-VI)from subjects other than Mathematics.

P.G. I (SEMESTER-I), PAPER-VI

MINOR ELECTIVE-PROBABILITY & STATISTICS
(For students, other than students of Mathematics)

Course Code: MMHM-406	**Credits-4** **Marks: 25+75**	**Minor Elective**
Total No. of Lectures-Tutorials (in hours per week): 4	**Course Title:** **PROBABILITY&STATISTICS**	

Course Objectives: The main objective of this course is to introduce the students (of other subjects) to basic concepts of Probability and Statistics so that they are able to use the tools of statistics in their subjects as well as their research work, specially to analyze the data.The applications of this course include business and engineering problems involving probability, curve fitting measures of dispersionand much more.

Unit	Topics	No. of Lectures
I	**Counting principles and basic theory of Probability:**Combinationsand permutations, Random experiment, sample space, event, definition of probability, Laws of probability, Probability of pairwise independent events.Conditional probability**,** Bayes theorem and its applications.	15
II	**Measures of Dispersion:**Review of mean, median and mode, Various measures of dispersion, Minimal property of mean deviation, Root mean square deviation, Variance and standard deviation,	15
III	**Curve fitting:** Moments about mean, origin, and any point, Skewness, Kurtosis, Pearson's β and γ – coefficients, Curve Fitting, Fitting of Straight lines**,** Fitting of second-degree parabola.	15
IV	**Correlation and Regression Analysis:** Significance of measuring correlation, Types of Correlation, Methods of measuring correlation, Regression Analysis, Lines of regression.	15

Course outcomes:

CO1: The students will be able to analyze and solve various concepts related to probability.

CO2: The students will be able to understand various concepts related to probability like conditionalprobability and Baye's Theorem.

CO3:The students will be able to study various measures of dispersion like range, mean deviation, quartile deviation and standard deviation.

CO4: The students will be able tofit various curves.

CO5: The students will be able toapply concept of correlation to study the relationship between two or more variables.

CO6: The students will be able tofind lines of regression of y on x and x on y which helps student to understand the use of forecasting.

Suggested Readings:

1. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2005): Fundamentals of Statistics, Vol. I, 8th Edn.World Press, Kolkata.
3. Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Mathematical Statistics, 11th Edn., (Reprint), Sultan Chand and Sons.
4. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of statistics, 3rdEdn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
5. Rohatgi, V. K. and Saleh, A. K. Md. E. (2009): An Introduction to Probability and Statistics, 2ndEdn. (Reprint), John Wiley and Sons.
6. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
7. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1994): Discrete Univariate Distributions, John Wiley.
8. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions, Vol. I & Vol. II, 2nd Edn., John Wiley.
9. Ross, S. M. (2007): Introduction to Probability Models, 9th Edn., Indian Reprint, Academic Press

M.A./M.Sc. I (SEMESTER-I), PAPER-VI
RESEARCH PROJECT

Course Code: MMHP-407	**Credits-4**	**Project**
	Course Title: RESEARCH PROJECT	
Course objectives: The objective to introduce research project is that the students are able to understand the nature of problem to be studied and identify the related area of knowledge, review literature to understand how others have approached or dealt with the problem.		
Each student will do a Research project, under the guidance of a supervisor. There will be a seminar presentation, based on research project at the end of the semester. Evaluation of the research project will be done after the second semester.		
Course outcome: The students are able to know how research problems can be approached.		

M.A./M.Sc. I(SEMESTER-II)

PAPER-I, FIELDS AND MODULES

Course Code: MMHC-411	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: FIELDS AND MODULES**	
Course Objectives: The aim of this course on Field Theory serves as the unifying thread which interlaces geometry, number theory, analysis, and even applied mathematics. The main objective to introduce the Module theory is that the students are able to know how the concepts of vector spaces have been generalized.		

Unit	**Topics**	**No. of Lectures**
I	Fieldtheory:Extensionfields.Algebraicandtranscendentalextensions.Splittingfield.	15

II	Separableandinseparable extensions, Normal extension. Perfect fields, Finite fields, Automorphisms of extensions, Galois group.Fundamentaltheorem of Galois theory.	20
III	Construction with ruler and compass. Insolvability of the general equation of degree 5 by radicals, Solution of polynomial equations by radicals.	10
IV	Modules, Cyclicmodules,Simplemodules,Semi-simplemodules,Schur'slemma, Noetherianand Artinianmodules,Hilbertbasistheorem.	15

Course outcomes:

CO1: The students are able to distinguish between rational, irrational, algebraic and transcendental numbers, constructible numbers.

CO2: By the time students complete the course,they will be able to use the Fundamental Theorem of algebra.

CO3: The students are able to analyzeGalois groups related to algebraic polynomials.

CO4: The students learn relationship and link between order of Galois Groups polynomials and the degree of Finite extensions.

CO4: The student is equipped with standard concepts and tools at advance level that will serve him/her well towards pursuing research in algebra.

Suggested Readings:

1. I.N. Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. P.B.Bhattacharya,S.K.JainandS.R.Nagpaul:BasicAbstractAlgebra(Second Edition),CambridgeUniversityPress,IndianEdition, 1997.
3. SurjeetSinghandQaziZameeruddin:ModernAlgebra,VikasPublishingHouse.Pvt.Ltd.,2005.
4. A.R.Vasishtha&A.K.Vasishtha:ModernAlgebra,KrishnaPrakashanMedia(P) Ltd., Meerut.
5. Luther, I.S. and I.B.S. Passi, Algebra Volumes I and II, Narosa Publishing House, New Delhi 1999.

M.A./M.Sc. I (SEMESTER-II), PAPER-II
TOPOLOGY-II

Course Code: MMHC-412	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** **TOPOLOGY-II**	

Course objectives: The main objective of this course is to recognize and apply advanced properties of, and techniques for topology to a range of important problems in Analysis, Geometry and Algebra.

Unit	Topics	No. of Lectures
I	Separatedsets.Connectednessintermsofseparatedsets.Characterizationof connectedsetsinterms ofopensetsandclosedsets.Closureofaconnectedset.Unionofconnectedset	20

	s,Connectedsetsin $\mathbb{R}$, Continuityofa functionandconnectedness.Componentsandpartitionofspace.	
II	Separation axioms − T_o, T_1, T_2, regular, T_3, normal and T_4-spaces, their comparison and examples, hereditary and topological invariant characters, Urysohn's lemma and Tietze extension theorem.	10
III	Inadequacyofsequentialconvergence,directedsets,netsandsubnetsandtheirexamplesConvergenceofanet,characterizationofopensets,closedsets,closure,clusterpointandlimitpointofaset, intermsofnet convergence.Hausdorffnessand continuityofafunctionintermsofnets. Definitionoffilteranditsexamples,Neighbourhoodfilter,Comparisonoffilters.Filterbaseand Convergenceofafilter,Ultrafilters,Continuousfunctionsandfilters,Net based on filter and filter based on net, Quotienttopology.	10
IV	Finiteproductspace,projectionmapping, Tychonoff product topology in terms standard subbase and its characterizations in terms of projection maps, continuous functions, Product of T_0,T_1,T_2, spaces. Connectedness and compactness, first and second countabilityfor productspaces.	20

Course outcomes:

CO1: The students are able to apply the concept of connectedness in other branches of Mathematics.

CO2: The students are able to know various degrees of strengths of separation axioms.

CO3: The students are able to know the need for generalization of concepts of sequences in topologyand so are able to know the importance of convergence of nets and filters.

CO4: The students are able to form not only larger topological spaces from the given topological space(s) with the help of product topology, but also, they are able to know the product invariant properties.

CO5: The students are able to define quotient topology.

Suggested Readings:

1. R. Munkres, Topology, A First Course, Pearson, N. Delhi, 2000.
2. W. J. Pervin, Foundation of General Topology, Academic Press Inc., New York, 1964.
3. J. L. Kelley, General Topology, D Van Nostrand Reinhold Co. New York 1955 (Reprinted by Springer Verlag, New York.
4. K. D. Joshi, Introduction to General Topology, New Age International (p) Ltd, 1983.
5. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by PHI).
6. N. Bourbaki, Topology I and II, Springer Verlag, New Delhi.
7. S. Willard, General Topology, Addison-Wesley, Reading, 1970. Reprinted by Dover.

8. L. A. Steen and J. A. Seebach, Counter Examples in Topology, Holt, Reinhart and Winston, Inc. New York, 1970.

M.A./M.Sc.I (SEMESTER-II), PAPER-III
PARTIAL DIFFERENTIAL EQUATIONS

Course Code: MMHC-413	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures-Tutorials (in hours per week): 4-1	**Course Title:** PARTIAL DIFFERENTIAL EQUATIONS	

Course objectives: The objective of this course is that the students are able to form first order Partial Differential Equations and also know to reduce second order Partial Differential Equations into canonical form and to find its solution. The students are able to learn the method of separation of variables and apply it to solve elliptic, parabolic and hyperbolic type of equations.

Unit	Topics	No. of Lectures
I	Classification of first order equations, General solutions of Quasi-linear equations, methodofcharacteristics, Cauchy's problems, canonical forms of first order linear equations, Method of separation of variables, Fully Non−linear firstorderpartialdifferentialequations,Jacobi'smethod.	15
II	Classificationof secondorderpartialdifferentialequations,Canonicalforms.Solutionofnon-linearsecondorderpartial differentialequationsbyMonge'smethod.	15
III	Methodofseparationofvariables,Laplace,waveanddiffusionequations and their solutions in Cartesian, cylindrical and spherical coordinate-systems.	15
IV	Solution of Wave, Heat and Laplace's Equations using Green's method.	15

Course outcomes:
CO1: Students will be able to apply the techniques for solving partial differential equations.
CO2: Students will be able to apply the methods learnt in this course, to calculate, compare and interpret the results obtained in other disciplines and determine whether the solutions are reasonable.
CO3: Students will be able todesign and develop viable opportunities for correlating the solutions of partial differential equations to different physical problems.
CO4: Towards the end, students will be able to evaluate and assess the results of various problems in other subjects based on these concepts.

Suggested Readings:

1.Ioannis P. Stavroulakis, Stepan A. Tersia, Partial Differential Equations(Second Edition) An Introduction with Mathematica and MAPLE.
2. I.N. Sneddon: Elements of Partial Differential Equations, Dover publications, Inc., 2006
3. K. Sankara Rao: Introduction to Partial Differential Equations, PHI, 2010.
4. T. Amarnath: An Elementary Course in Partial Differential Equations, Alpha science International Ltd., 2003.
5. TynMyint-U LoenathDebnath, LinearPartial Differential Equations for Scientist and Engineers Fourth Edition, 2007, Birkhauser Boston.

M.A./M.Sc.I (SEMESTER-II), PAPER-IV
ADVANCED REAL ANALYSIS

Course Code: MMHC-414	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures-Tutorials (in hours per week): 4-1	**Course Title:** ADVANCED REAL ANALYSIS	

Course objectives: The objective of this course is to introduce the advanced concepts of real analysis, e.g., convergence of sequence and series of functions, functions of bounded variations, absolute continuity, Riemann−Stieltjes integral, measurable sets and Lebesgue measure of various functions and the criteria for convergence of functions in measure theory.

Unit	Topics	No. of Lectures
I	**Sequence and series of functions, their convergence, function of bounded variations:** Sequences and series of functions of real numbers, pointwise convergence and uniform convergence, CauchyCriterionofuniformconvergence, Weierstrasstestforuniformconvergence, Uniformconvergenceandcontinuity, Uniformconvergenceandintegration,Uniformconvergenceanddifferentiation, Exampleofafunctionwhichiscontinuouseverywhereon thereal linebutnowheredifferentiable.Functionsofboundedvariationandtheirproperties, absolutelycontinuousfunctionsandtheirproperties, relationbetweenabsolutecontinuityandfunctionofboundedvariation.	15

II	**Riemann−Stieltjes integration and their properties:** Riemann−Stieltjes integration w.r.t. arbitrary integrator, Existence of Riemann−Stieltjes integrals, Integration bypartstheorem, PropertiesofR-Sintegrablefunctions, Interchangeofintegrandandintegratorfunctions.Uniformconvergenceand R-S integration. Evaluation ofR-S integrals, R-S integralsand sequence ofintegrator functions.	15
III	**σ−algebra, Lebesgue measurable sets and measurable space:** InadequacyofRiemannintegration,Lebesgue'soutermeasure λ anditsproperties.Lengthof anintervalandLebesgueoutermeasure μ, LebesguemeasurablesetsinRandσ−algebraofLebesguemeasurablesets M_λ inR, Lebesguemeasurabilityofopensets,closedsetsandBorelsets,LebesguemeasureonR.ExampleofaNon-Lebesguemeasurableset,Cantor'ssetanditsLebesguemeasure.	15
IV	**Measurable functions and convergence in measure:** Definitionofameasurablefunction, Equivalentconditionsformeasurablefunction, Sumandproductofmeasurable functions, Composition of a measurable and a continuous function. Sequences of measurable functions,Measurability of supremum function, infimum function, limit superior function, limit inferior function and limit function,Simple measurable functions. and their properties, A non−negative measurable function as the limit of a sequence ofnon−negative simple measurable functions, Concept of almost everywhere (a.e.), Measurability ofRiemann integrablefunctions.ConvergenceinMeasureanditsproperties,F.RiesztheoremandEgorovtheorem,Convergencealmosteverywhere,almostuniformconvergenceandtheirinter−relations.	15

Course outcomes:

CO1: The students will be able to check the convergence of sequence and series of functions.

CO2: The students will be able to determine Riemann−Stieltjes integral of functions

CO3: The students will be able tofind the measure of a set, and distinguish between measurable and non-measurable sets.

CO4: Towards the end, the students will be able to compute the measure of functions. Test the convergence of sequence of measurable functions.

Suggested Readings:

1. W.Rudin, Principles of Mathematical Analysis, McGraw Hill ,1983.
2. T.M.Apostol, Mathematical Analysis, 2nd edition, Narosa,1988.
3. H.L.Royden, RealAnalysis,MacmillanPub.Co.Inc.NewYork,4thEdition,1993.

M.A./M.Sc. I (SEMESTER-II), PAPER-V
NUMERICAL METHODS WITH PRGRAMMING IN C

Course Code: MMHL-415	**Credits-4** **Marks: 25+75**	**Practical**
Total No. of Lectures-Practicals (in hours per week):4-4	**Course Title:** NUMERICAL METHODS WITH PRGRAMMING IN C	

Couse objective: The lab component of this course aims to design the programmesusing C for various numerical methods covered in the course.

Practical:
NumericalMethodswithProgramminginC

1. ToimplementNewton-Raphsonmethod.
2. ToimplementNewton'sforward/backwardinterpolationformula.
3. ToimplementLagrange'sinterpolationformula.
4. ToimplementTrapezoidalrule.
5. ToimplementSimpson'sonethirdrule.
6. To implementGauss-eliminationmethod.
7. To implementGauss-Jordanmethod.
8. ToimplementCrout'smethod.
9. ToimplementJacobi'smethod.
10. To implementGauss-Seidelmethod.
11. ToimplementSORmethod

Course outcomes:
CO1: The students will be able to write efficient and well documented programmes forvarious numerical methods and present outputs in an informative way
CO2: The students will be able to appreciate the use of C-programming for finding the numerical solutions by using different methods.

Suggested Readings:

1. E. Balagurusamy: Programming in ANSI C, MacGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. PrahladTiwari,R.S.ChandelandA.K.Tripathi:ProgramminginC&NumericalAnalysis,RamPrasad&Sons,Agra.
3. S. S.Sastry:IntroductoryMethodsofNumericalAnalysis,PHI,NewDelhi.
4. Madhumangal Pal, Numerical Analysis for Scientists and Engineers () Theory and C Programs), Narosa Publishing House, 2008.
5. B.S.Grewal, Numerical Methods in Engineering & Science with Programs in C, C++& MATLAB, Khanna Publishers.

M.A./M.Sc. I (SEMESTER-II), PAPER-VI
RESEARCH PROJECT/DISSERTATION

Course Code: MMHP-416	**Credits-4** **Marks-100**	**Project**
	Course Title: RESEARCH PROJECT	

Course objectives: The objective to introduce research project is that the students are able to understand the nature of problem to be studied and identify the related area of knowledge, review literature to understand how others have approached or dealt with the problem.

Evaluation of the research project will be done on completion of second semester.

Course outcome: The students are able to do research problems.

M.A./M.Sc. II (SEMESTER-III), PAPER-I

ADVANCED COMPLEX ANALYSIS

Course Code: MMHC-501	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** ADVANCED COMPLEX ANALYSIS	

Course objectives:

Theobjective of the course is to develop those parts of the theory that are prominent in application of complex analysis.In this course students will learn important concepts of complex analysis, likeAnalytic continuationand conformal mapping.

Unit	Topics	No. of Lectures
I	Analyticcontinuation.Uniquenessofanalyticcontinuation.Powerseriesmethodofanalytic continuation.Branchesofmany−valuedfunction.Singularitiesofananalyticfunction,Riemannsurfaces.	15
II	Gammafunction.ZetaFunction.Principleofreflection,Hadamard'smultiplicationtheorem. Functions withnaturalboundaries.	15
III	Maximum−modulustheorem.Schwarz'slemma.Vitali'sconvergencetheorem.Hadamard'sthree−circlestheorem.Mean valuesof$\|f(z)\|$. Borel−Caratheodorytheorem, Pharagmen−Lindelof theorem.	15
IV	Conformalrepresentation. Linear(bilinear)transformationsinvolvingcirclesandhalf−planes,Transformations$w=z^2$,$w=(z+1/z)/2$, $w=\log z$,$w=\tan^2(z/2)$, Simplefunctionanditsproperties,The''1/4 theorem''. Radiusofconvergenceofthepowerseries,Analyticityofsumofpowerseries,Positionofthesingularities.	15

Course outcomes:

CO1: The students will be able to understand and have knowledge and skills to identify the fundamental concepts of complex analysis and analyse their role in modern mathematics and applied contexts.

CO2: The students will be able to apply the concepts to explain accurate and efficient use of complex analysis techniques so that they can demonstrate the capacity in problem-solving, analyzing and proving from complex analysis.

CO3: The students will be able to apply and link complex analysis theory and techniques to solve a variety of diverse situations in physics, engineering and other mathematical areas at an appropriate level of difficulty.

Suggested Readings:

1. J.B. Conway, Complex Analysis (2nd Ed.), Narosa Publishing House, New Delhi

2. Ruel V. Churchill, Complex Variables and Applications (Eight Edition), Tata McGraw Hill,2009
3. H. A. Priestly, Introduction to Complex Analysis, Oxford University Press, Clarendon Press, 1990
4. L.V. Ahlfors, Complex Analysis, Tata McGraw Hill Publishing Co. Limited New Delhi 1966.
5. E.C. Titchmarsh: Theory of Functions, Oxford University Press, London.
6. ShantiNarayan:TheoryofFunctionsofaComplexVariable,S.Chand&Co.,NewDelhi.
7. MarkJ.AblowitzandA.S.Fokas:ComplexVariables:IntroductionandApplications,CambridgeUniversityPress,South Asian Edition,1998.

M.A./M.Sc. II (SEMESTER-III), PAPER-II

BANACH SPACES

Course Code: MMHC-502	**Credit** **Marks: 2**
Total No. of Lectures (in hours per week) - 4	

Course objectives: The objective of this course is to familiarize the students with the basic concepts, principles provides a unifying framework for many areas of mathematics.

Unit	Topics
I	Normedlinearspaces,Banachspaces,theirexamplesincludingR^n,C^n, ℓ^p (n), ℓ^p ,for $1 \leq p < \infty$, c_0 ,c,C[a,b], J completeness, Subspaces, Quotient spaces of normed linear space and itscompleteness.
II	Continuousandboundedlinearoperatorsandtheirbasicproperties,Normedlinearspaceofboundedlinear operat
III	Isometricisomorphism,Topologicalisomorphism,Equivalentnorms.Finitedimensionalnormedspacesandcon c_0,ℓ^p (n), ℓ^p.
IV	Hahn– Banach theorem for real and complex normed linear theoremanditssimpleconsequences,Productnormedspace,Closedgraphtheorem.Uniformboundedness,Banach-Steinhaus t

Course outcomes:
CO1: The students will be able toidentify the abstract structure of Infinite dimensional normed space and develop
CO2: It provides an impressive illustration of the unifying power of functional analytic methods in linea
approximation theory and linear Integral equations.
CO3: The students will be able to classify the functional analytic methods and results in various field of mathema
CO4: Thestudents will be able to understand the importance of Hahn- Banach Theorem,Open mapping theorem,

Suggested Readings:

1. E. Kreyszig: Introductory Functional Analysis with Applications, John Willey & sons, New York, 1978.
2. W. Rudin: Functional Analysis, Tata Mc Graw- Hill, New Delhi, 1977.
3. P.K.Jain,O.P.AhujaandK.Ahmad:FunctionalAnalysis,NewAgeInternational(P)Ltd.andWileyEasternLtd.,New Delhi,19
4. F. B. Choudhary & S. Nanda: Functional Analysis with Applications, Wiley Eastern Ltd., 1989.
5. I.J Maddox: Functional Analysis, Cambridge University Press,1970.
6. G.F.Simmons:IntroductiontoTopologyandModernAnalysis,McGraw−HillBookCompany,NewYork,1963.

7.K.ChandrashekharaRao:FunctionalAnalysis,NarosaPublishingHouse,NewDelhi.

M.A./M.Sc. II (SEMESTER-III), PAPER-III

ANALYTICAL DYNAMICS

Course Code: MMHE-503(a)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** ANALYTICAL DYNAMICS	

Course objectives: Analytical Dynamics is one of the essential and fundamental links between body motion and its causes, specifically the forces acting on the bodies and their properties, particularly mass and moment of inertia. The main objective of the course is to explore the dynamics of bodies in depth in this study.

Unit	Topics	No. of Lectures
I	Classification of dynamical systems,generalized coordinates, Holonomic and non-holonomic systems, Kinetic energy,generalized components of momentum, Generalized components of the effective and applied forces.	15
II	Lagrange's equations, Examples include the Energy equation from Lagrange's equation, Reciprocal relations, Lagrange's equation for impulsive motion, Ignoration of coordinates, The Routhian function, Euler's equation from Lagrange's equation.	15
III	Hamilton's equations of motion. Application of Hamiltonian methods. Natural motions, The space of events. Action, Hamilton's principle. Principle of least action, Hamilton-Jacobi equation, Hamilton	15

	characteristic function, Generating function.	
IV	Canonical transformations, Phase space, Bilinear invariants, Poisson brackets, Lagrange brackets, Invariance of Lagrange brackets and Poisson brackets under canonical transformations. Small oscillations, Lagrange's determinants, Normal modes, normal coordinates and their stationary properties.	15

Course outcomes:

CO1: The students will be able to classify dynamical systems, and define generalized coordinates, generalized components of momentum and effective applied forces.
CO2: The students will be able to define Lagrange's equations for energy, impulsive motion.
CO3: The students will be able to explain Hamiltonian's equations of motion, principle of least action, Poisson's brackets, Lagrange's equation of small oscillations.
CO4:The students will be able to define normal modes and normal coordinates and relatedconcepts.

Suggested Readings:

1. S.L.Loney:AnElementaryTreatiseontheDynamicsofaParticleandofRigidBodies,MacmillanIndiaLtd.,1982.
2. A.S.Ramsey:DynamicsPart−II,TheEnglishLanguageBookSocietyandCambridgeUniversityPress,1972.
3. J.L. Synge and B.A. Griffith: Principles of Mechanics, McGraw Hill International Book Company, 1982.
4. L. N. Hand and J. D. Finch: Analytical Mechanics, Cambridge University Press, 1998.
5. Naveen Kumar: Generalized Motion of Rigid Body, Narosa, 2004.

M.A./M.Sc. II (SEMESTER-III) PAPER-III

FOURIER ANALYSIS

Course Code: MMHE-503(b)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: FOURIER ANALYSIS**	

Course outcomes: The objective of this course is to provide an understanding of Fourier series, their convergence and Fourier transform and inverse Fourier transforms, and practice their application.

Unit	Topics	No. of Lectures
I	Fourier Series: Definition, uniqueness, convolution, summability.	15
II	Convergence of Fourier Series. Riemann-Lebesgue lemma, A continuous function with divergent Fourier series, Parseval's identity, Weierstrass approximation theorem.	15

III	Schwartz space on R, Fourier transform on the Schwartz space, Fourier transform of integrable and square-integrable functions, Poisson summation formula, Plancherel formula.	15
IV	Applications: Uncertainty principle, Shannon sampling theorem.	15

Course outcomes:
CO1: The students will be able to derive a Fourier series of a given function by evaluating Fourier coefficients.
CO2: The students will be able to give a continuous function with divergent Fourier series.
CO3: The students will be able to calculate the Fourier transform or inverse transform of some functions.
CO4: The students will be able to understand Poisson summation formula, Plancherel formula.
CO5:The students will be able to learn some applications of Fourier Series and Fourier transform.

Suggested readings:

1. Stein E., Shakarchi R. Fourier Analysis. An Introduction; Princeton Lectures in Analysis, Princeton University Press.

M.A./M.Sc. II (SEMESTER-III) PAPER-III
CRYPTOGRAPHY

Course Code: MMHE-503(c)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** CRYPTOGRAPHY	

Course objectives:

The objective of the course is to introduce the basic theory of Cryptography and Network Security. The purpose of the course is to give a simple account of cryptography including the notation of Caesar Cipher, Stream cipher and Diffie-Hellman RSA public key cryptosystem.

Unit	Topics	No. of Lectures
I	Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques- Substitution and transposition ciphers, Caesar cipher, Play fair cipher, Block cipher Principles, Shannon theory of diffusion and confusion,Data encryption standard (DES).	15
II	Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2n), Fermat theorem and Euler's theorem (statement only), Chinese Remainder theorem, Discrete logarithm.	15
III	Advanced Encryption Standard (AES), Stream ciphers, Introduction to public key cryptography, one-way functions, The discrete logarithm problem, Diffie-Hellman key exchange algorithm, RSA algorithm and security of RSA, The ElGamal public key cryptosystem, Introduction to elliptic curve cryptography.	15

IV	Information/Computer Security: Basic security objectives, security attacks,security services, Network security model, Cryptographic Hash functions, Secure Hash algorithm, SHA-3. Digital signature, Elgamal signature, Digital signature standards, Digital signature algorithm.	15

Course outcomes:

CO1: The students will be able toknow the basic theory of Cryptography and Network Security.

CO2: The students will be able to secure a message over insecure channel by various means and also understand various protocols for network security to protect against the threats in the networks.

Suggested readings:

1. William Stallings, Cryptography and Network Security, Principles and Practice, 5^{th} ed., Pearson Education, 2012.
2. Douglas R. Stinson, Cryptography: Theory and Practice, CRC Press, 3^{rd} ed., 2005.
3. J.A. Buchmann, Introduction to Cryptography, 2^{nd} ed., Springer 2003.
4. W. Trappe and L.C. Washington, Introduction to Cryptography with Coding Theory, Pearson, 2006.
5. J. Hoffstein, J. Pipher, and J. H. Silverman, An Introduction to Mathematical Cryptography, 2^{nd} ed., Springer, 2014.

M.A./M.Sc. II (SEMESTER-III) PAPER-III

RIEMANNIAN GEOMETRY

Course Code: MMHE-503(d)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: RIEMANNIAN GEOMETRY**	

Course objectives: The first aim of this course is to give a thorough introduction to the theory of manifolds, which are the fundamental objects in Differential Geometry. The second aim is to describe the basics of Riemannian Geometry, in particular the notion of geodesics and curvature.

Unit	Topics	No. of Lectures
I	Curvature of a curve, Principal normal. Geodesics, Geodesic and Riemannian coordinates, Geodesic form of the linear element, Parallelism of a vector of constant/variable magnitude.	15
II	Congruences and orthogonal ennuples, Ricci's coefficients of rotation. Curvature of a congruence. Geodesic congruence, Reason for the name "coefficient of rotation", Normal congruence. Irrotational congruence. Congruences canonical with respect to a given congruence.	15

III	Riemannian curvature tensor, Its contraction. Covariant curvature tensor. Bianchi's identity, Riemannian curvature of a V_n, Theorem of Schur, Mean curvature of a space for a given direction.	15
IV	Projective and conformal transformations, Weyl's projective and conformalcurvature tensors and their properties.	15

Course outcomes:

CO1: The students will be able to define curvature of curve and Geodesic and its applications.
CO2: The students will be able to define congruences and orthogonal ennuples and Ricci's coefficients of rotation, curvature of congruence.
CO3: The students will be able to define Riemannian curvature of n-dimensional space and Schur's theorem.
CO4:The students will be able to defineprojective and conformal transformation (Weyl's projective).

Suggested readings:

1. C. E. Weatherburn: An Introduction to Riemannian. Geometry and the Tensor Calculus, Cambridge University Press, 1966.
2. R. S. Mishra: A Course in Tensors with Applications to Riemannian Geometry, Pothishala (Pvt.) Ltd., 1965.
3. L. P. Eisenhart: Riemannian Geometry, Princeton University Press, 1997.
4. T. J. Willmore: An Introduction to Differential Geometry, Dover Publications, 2013.

M.A./M.Sc. II (SEMESTER-III) PAPER-III

GENERAL RELATIVITY

Course Code: MMHE-503(e)	
Total No. of Lectures (in hours per week) - 4	**Course Title: GENER**

Course Objectives: The course provides a comprehensive introduction to general theory of relativity. The int
General Relativity.

Unit	**Topics**
I	Transformationofcoordinates,transformationlawoftensor,Productoftwotensor,Contraction,Traceofatensor, quotientlaw,MetrictensorandRiemannianspace,Conjugatetensor,symmetricandanti−tensor,Tensordensity,Levi-C Tensor form of gradient, divergence, Laplacian and Curl, Riemannian and normal null coordinate, Gaussia

II	Parallel transport, Riemannian curvature tensor, Parallel propagation identities,Conformalcurvaturetensor,ConformalInvariance,Geodesicdeviation,Liederivativesincurvedspacetime,
III	Introduction to General Relativity, Principle of Equivalence, Euclideancharacterofrotatingdisc,geodesicpostulate,Newtonianapproximationofequationofmotion,SearchforEins Clock Paradox, Schwarzschild exteriorsolution, Singularities in Schwarzschild line element,Isotropic form of Echo delay (Fourth Test).
IV	Analogous to Kepler's Law, Energy momentum tensor, Formula for energy momentum tensor for perfect fluid, equation from variationalprinciple,Energymomentumpseudotensor,Gravitationalwavesweakfieldequations,Grav

Course outcomes:

CO1: The students will be able tounderstand metric tensor and Riemannian space.

CO2: The students will be able to learn Ricci tensor, Bianchi Identities, examples of symmetric space time.

CO3:The students will be able to understand Einstein's field equation, gravitational waves in empty space.

Suggested readings:

1. K. D. Krori: Fundamentals of Special and General Relativity; PHI Publication, 2010.
2. S.R.RoyandRajBali:TheoryofRelativity;JaipurPublishingHouse,2008.
3. Steven Weinberg: Gravitation and Cosmology: Principles and applications of General Relativity; Wiley Publication,
4. J.V.Narlikar:AnIntroductionstoRelativity;CambridgeUniversityPress,2010.
5. I.B.Khriplovich:GeneralRelativity;SpringerScience&Businessmedia,2005.
6. S.K Srivastava: General Relativity and Cosmology, PHI.

M.A./M.Sc. II (SEMESTER-III) PAPER-III

MACHINE LEARNING

Course Code: MMHE-503(f)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: MACHINE LEARNING**	

Course objectives: This course aims to introduce theories and methods for automating and representing knowledge with an emphasis on learning from input/output data. The course covers a wide variety of approaches, including Supervised Learning, Neural Nets and Deep Learning, Reinforcement Learning, Expert Systemsand Bayesian Learning.

Unit	Topics	No. of Lectures

I	Introduction to Machine Learning (ML), History and Applications of ML, Recent trends in Machine Learning, Learning, Types of Learning, designing a Learning System, Introduction of Machine Learning Approaches, Understanding of Data and Datasets, Features Extraction, Features selection, Feature selection Mechanisms, Train, Test and Validation Sets, Imbalanced data, Outliers, over fitting and Under fitting, Confusion Matrix, Performance Metrics: Accuracy, Precision, Recall, F-1 Score, Data Science vs Machine Learning.	15
II	**SUPERVISED LEARNING(REGRESSION/CLASSIFICATION)**: Distance-based methods, Euclidean and Manhattan Distances, NearestNeighbours,Regression: Linear Regression, Cost Function, Multiple Linear Regressions, Logistic Regression. Classification: Decision Trees, Classification and Regression Trees (CART), Naive Bayes Classifiers, k-Nearest Neighbor (KNN), Support Vector Machines (SVM), Neural Networks (refer to unit –III). **UNSUPERVISED LEARNING:**Clustering Algorithms: k-Means clustering, Hierarchical Clustering, Probabilistic Clustering, Dimensionality Reduction, Principal components analysis (PCA),	15
III	**Neural Network:** Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks, Linear and nonlinear Separable Problem, Linear and nonlinear activation functions, Perceptron, Perceptron Convergence Theorem, single layer artificial neural network, multilayer perception model; Derivation of back propagation algorithm, applications.	15
IV	**Introduction to Bayesian Learning**: Bayes theorem, Concept Learning, Bayes Optimal Classifier, Naïve Bayes classifier, Bayesian belief networks, Expectation Maximization Algorithm, Semi-supervised Learning, Active Learning, Reinforcement Learning, Example of Reinforcement, Learning in Practice, Q-Learning.	15

Course outcomes:

CO1: The students will be able to understand the need for machine learning for various problem solving.

CO2: The students will be able tounderstand a wide variety of learning algorithms and know how to evaluate models generated from data.

CO3:The students will be able to understand the latest trends in machine learning.

CO4: The students will be able toidentify appropriate machine learning algorithms for general real-world problems and apply these algorithms to solve these problems.

Suggested readings:

1. EthemAlpaydin: Introduction to Machine Learning, MIT Press, Prentice Hall of India, 3rd Edition, 2014.
2. MehryarMohri, Afshin Rostamizadeh, Ameet Talwalkar: Foundations of Machine Learning, MIT Press,2012.
3. Tom Mitchell: Machine Learning, McGraw Hill, 3rdEdition, 1997.
4. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Second Edition, 2015.
5. Bishop, C., Pattern Recognition and Machine Learning, Berlin: Springer-Verlag.
6. SimanHaykin: Neural Netowrks, Pearson Education.
7. A. Srinivasaraghavan, Vincy Joseph: Machine Learning, Wiley, 2019.

M.A./M.Sc. II (SEMESTER-III), PAPER-III

MATHEMATICAL STATISTICS

Course Code: MMHE-513(g)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** **MATHEMATICAL STATISTICS**	

Course objectives: The aim of the course is to enable the students with understanding of various types of probability distributions and testing of hypothesis problems. It aims to equip the students with standard concepts of statistical techniques and their utilization.

Unit	Topics	No. of Lectures
I	Random variable, Probability mass function, Probability density function, Cumulative distribution function, Two and higher dimensional random variables, Joint distribution, Marginal and conditional distributions, Stochastic independence, Function of random variables and their probability density functions. Discrete probability distributions: Binomial, Poisson, Geometric, Hyper geometric multinomial, Continuous probability distributions: Exponential, Gamma, Beta, Normal distributions.	15
II	Mathematical expectations and moments, Moment generating function and its properties, Chebyshev's inequality and its application, Stochastic convergence, Central limit theorem, Partial and Multiple correlation coefficients, Correlation ratio, Association of attributes.	15
III	**Sampling Distributions**: Chi-square, t and F-distributions with their properties, Distribution of sample mean and variance, Distribution of order statistics and sample range from continuous populations. **Applications of Sampling Distributions**: Test of mean and variance in the normal distribution, Tests of single proportion and equality of two proportions, Chi-square test, t-test, F-test.	15

IV	**Testing of Hypothesis**: Null hypothesis and its test of significance, Simple and composite hypothesis, MP test, UMP test, Likelihood tests (excluding properties of likelihood ratio tests). **Point Estimation**: Estimators, Properties of estimators, Unbiasedness, Consistency, Sufficiency, Efficiency.	15

Course outcomes:

CO1: The students will be able to explain random variables, probability distributions.
CO2: The students will be able to define mathematical expectations and moments.
CO3: The students will be able to understand sampling distributions and their applications.
CO4: The students will be able to understand testing of hypothesis.

Suggested readings:

1. Hogg R.V., Mckean, J. W. and Craig A. T.: Introduction of Mathematical Statistics, Seventh Edition Pearson India, 2013.
2. Hoel P. G: Introduction to Mathematical Statistics, Fourth Edition, John Wiley & sons, 1971.
3. Gupta S. C.and Kapoor V. K.: Fundamentals of Mathematical Statistics, Kedarnath Ramnath Pub., Meerut India, 2019.

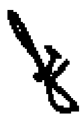
M.A./M.Sc. II (SEMESTER-III), PAPER-IV

FLUID DYNAMICS

Course Code: MMHE-504(a)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: FLUID DYNAMICS**	

Course objectives: Prepare a foundation to understand the motion of fluid and develop concept, models and which enables to solve the problems of fluid flow and help in advanced studies and research in the broad a motion.

Unit	Topics
I	Wavemotioninagas,SpeedofSound.Equationofmotionofagas.Subsonic,sonicandsupersonicflowsofa gas,Isentropicgasflows,Flowthroughnozzle,Shockformation.Elementaryanalysisofnormalandobliqueshockwaves Derivationofspeedofshockformedbysuddenmovementofpistoninagasatrest.
II	Stress components in a real fluid. Relations between Cartesian components of stress. Rate of strain quadric Principalstresses.Relationsbetweenstressandrateofstrain.
III	Coefficientofviscosity,Navier−Stokesequationsof motion,Steadyviscousflowbetweenparallelplanesandthroughtubesofuniformcircularcross-sections,Steadyflow betweenconcentricrotatingcylinders.Diffusionofvorticity,Energydissipationduetoviscosity,Reynoldsnumber.
IV	Dimensional Analysis, Steady flow between parallel plates, Poiseuille flow, Steady flow between concentric rotating cylinders, Stokes first and second problems.



Course outcomes:

CO1: The students will be able toexplain concepts of wave motion in gas, speed of light, subsonic, sonic and flows of gas, shock formation and shock waves.

CO2: The students will be able todefine stress components in a real fluid, Navier-Stokes equations of motion.

CO3: The students will be able explain concepts of steady viscous flow, diffusion of vorticity, Reynolds number.

Suggested readings:

1. F. Chorlton, Text Book of Fluid Dynamics, CBS Publisher, 2005.
2. R.W. Fox, P.J. Pritchard and A.T. McDonald, Introduction to Fluid Mechanics, Seventh Edition, Joh Sons, 2009.
3. P.K. Kundu, I.M. Cohen, D.R. Dowling, Fluid Mechanics, Sixth Edition, Academic Press, 2016.

M.A./M.Sc. II (SEMESTER-III), PAPER-IV

COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

Course Code: MMHE-504(b)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** **COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS**	

Course objectives: The objective of this course is not only to introduce the basic concepts in the numerical solution of partial differential equations, but also formulate numerical methods for solving partial differential equations and study their properties.

Unit	Topics	No. of Lectures
I	Finite difference methods for 2D and 3D elliptic boundary value problems (BVPs) of second approximations; Finite difference approximations to Poisson's equation in cylindrical and spherical polar coordinates; Solution of large system of algebraic equations corresponding to discrete problems and iterative methods (Jacobi, Gauss-Seidel and SOR); Alternating direction methods.	15
II	Different 2- and 3-level explicit and implicit finite difference approximations to heat conduction equation with Dirichlet and Neumann boundary conditions; Stability analysis, compatibility, consistency and convergence of the difference methods; ADI methods for 2- & 3-D parabolic equations, Finite difference approximations to heat equation in polar coordinates.	15
III	Methods of characteristics for evolution problem of hyperbolic type; explicit and implicit difference schemes for first order1- & 2D hyperbolic equations and their stability and consistency analysis; System of equations for first order hyperbolic equations;	15
IV	Finite element methods for second order elliptic BVPs, Finite element equations; Variational problems, Triangular and rectangular finite elements; Standard examples of finite elements, Finite element methods for parabolic initial and boundary value problems.	15

Course outcomes: **CO1:** The students will be able to formulate and use discretization methods for the numerical solution of partial differential equations using finite difference schemes. **CO2**: The students will be able to analyze the consistency, stability and convergence of a given numerical scheme. **CO3:** The students will be able to explain what kind of numerical schemes are best suited for each type of PDEs (hyperbolic, parabolic and elliptic) and the reasons behind these choices. **CO4**: The students will be able to understand and apply various iterative techniques for solving system of algebraic equations. **CO5**: The students will be able to demonstrate familiarity with the basics of finite element methods for the numerical solution of partial differential equations. **CO6:**The students will be able to construct computer programme using some mathematical software to test and implement numerical schemes studied in the course.
Suggested readings: 1. J. Davies, The finite element method: An introduction with partial differential equations, Oxford University Press, 2011. 2. C. Johnson, Numerical Solution of Partial Differential Equations by Finite Element Methods, Cambridge University Press, 1987. 3. K.W. Morton and D. Mayers, Numerical Solution of Partial Differential equations, Cambridge University Press, 2005. 4. J.C. Strickwerda, Finite Difference Schemes & Partial Differential Equations, SIAM publications, 2004. 5. J.W.Thomas, Numerical Partial Differential Equations: Finite Difference Methods, 47 Springer and Verlag, Berlin, 1998. 6. J.W.Thomas, Numerical Partial Differential Equations: Conservation Laws and Elliptic Equations, Springer and Verlag, Berlin, 1999.

M.A./M.Sc. II (SEMESTER-III), PAPER-IV

BIO-MATHEMATICS

Course Code: MMHE-504(c)	**Max. Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: BIO-MATHEMATICS**	
Course objectives: This course aims to introduce the fundamental of applying mathematical modelling techniques to understanding and predicting the dynamics of biological systems.		

Unit	Topics	No. of Lectures
I	Introduction, Definition and Scope of Bio-Mathematics, Role of Mathematics in Bio sciences. Basic concepts of Fluid Dynamics, Bio-Fluid Dynamics.	15
II	Basic concepts about blood, Cardiovascular system and blood flows, Blood flow through artery with mild stenosis, Two-layered flow in a tube with mild stenosis, Pulsatile Flow of Blood. Peristaltic flow in tubes and channels.	15

III	Gas exchange and air flow in lungs. Consumption and transport of Oxygen, Weibel's model for flows in lung airways, Comparison between flows of blood and flows in lung airways.	15
IV	Diffusion, Fick's laws of diffusion, Diffusion equation, Modification of the diffusion equation. Diffusion in artificial kidney, Hemodialyser. Types of Hemodialyser.	15

Course outcomes:

CO1: The students will be able to employ theoretical analysis, mathematical models and abstractions of the living organisms to investigate the principles that govern the structure, development and behaviour of the systems, as opposed to experimental biology which deals with the conduction of experiments to prove and validate the scientific theories.

Suggested Readings:

1. J. N. Kapur: Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd., New Delhi, 1985.
2. Y. C. Fung: Bio−Mechanics, Springer−VerlagNewYorkInc.,1990.
3. Stanley E. Charm and George S. Kurland: Blood Flow and Micro circulation, John Wiley &Sons,1974.
4. S. A. Levin: Frontiers in Mathematical Biology, Springer−Verlag, 1994.
5. S. K. Pundir& R. Pundir: Biomathematics, Pragati Prakashan, 2010.

M.A./M.Sc. II (SEMESTER-III), PAPER-IV

DIFFERENTIAL GEOMETRY OF MANIFOLDS

Course Code: MMHE-504(d)	**Credits-4** **Marks: 25+75**	**Elective pa**
Total No. of Lectures (in hours per week) - 4	**Course Title: DIFFERENTIAL GEOMETRY OFMANIFOL**	

Course Objectives: The course aims to introduce the basic ideas of differentiable manifolds. In this course we give an in the theory of manifolds, including their definition and examples; vector fields, Riemannian Manifold, Exterior product o etc.

Unit	Topics
I	Tensor Algebra, Dual space, Tensor product of vector spaces. Tensors of type (r, s), Tensor product of tensors, Algebraic operations, Contraction, Symmetric and skew-symmetric tensors. Exterior product of two vectors, Exterior algebra of order r.
II	Exterior derivative,Invariantviewpointofconnections,Covariantdifferentiation,Torsion,Curvature,Parallelism,Differencetensor of two connections, Liederivative.
III	Riemannian Manifold, Riemannian connection, Riemannian curvature tensor and Ricci tensor, Identities ofBianchi, Sectional curvature.

IV	Definitionandexamplesofdifferentiablemanifold,Differentiablefunctions.Differentiablecurves, Tangentspace, Vector fields, Lie bracket, Submanifolds,Normals,Inducedconnection,Gaussformulae,Weingartenformulae,Linesofcurvature,Mean curvature,EquationsofGaussandCodazzi.

Course outcomes:

CO1: The students will be able to explain the concept of a manifold and give examples. **CO2**: The st be able to describe vector fields from different points of view and indicate thelinks between them.

CO3: The students will be able to work effectively with tensor fields and differential forms on manifolds.

Suggested Readings:

1. B.B.Sinha: AnIntroductiontoModernDifferentialGeometry,Kalyani Publishers, New Delhi,1982.
2. N.J.Hickls:NotesonDifferentialGeometry.
3. K.YanoandM.Kon:StructureofManifolds,WorldScientificPublishingCo.Pvt. Ltd., 1984.

M.A./M.Sc. II (SEMESTER-III) PAPER-IV

SPHERICAL ASTRONOMY-I

Course Code: MMHE-504(e)	Credits-4 Marks: 25+75	Elective paper
Total No. of Lectures (in hours per week) - 4	**Course Title:** SPHERICAL ASTRONOMY-I	

Course objectives: The objective of this course is to describe the science of cosmology and its relation to other fields of science.

Unit	Topics	No. of Lectures
I	Simple relations between trigonometrical functions of the sides and angles of a spherical triangle, Solution of triangles, Area of a spherical triangle, Spherical excess.	15
II	Refraction, Parallel plate formula, homogeneous shell, concentric layers of varying density, differential equation for refraction, refraction right ascension and declination.	15
III	Precession and nutation, Precession and nutation in right ascension and declination,independentdaynumbers,Aberration in longitude and latitude; right ascension and declination, aberrational ellipse.	15
IV	Geocentric and heliocentric parallax, geocentric parallax in zenith distance, lunar parallax in right ascension and declination, stellar parallax in longitude and latitude.	15

Course outcomes:

CO1: The students will be able to know differential equation of refraction.

CO2: The students will be able to explain precession and nutation.

CO3: The students will be able to explain geocentric and heliocentric parallax.

Suggested readings: 1. Gorakh Prasad: A Text book onSpherical Astronomy, Pothishala (Pvt.) Ltd. 2. Ball: A Text book of Spherical Astronomy.

M.A./M.Sc. II (SEMESTER-III), PAPER-IV
SPECIAL FUNCTIONS-I

Course Code: MMHE-504(f)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** SPECIAL FUNCTIONS-I	

Course Objectives: To understand the properties of special functions like Gamma function, hypergeometric fu
and Legendre functions, and how special function is useful in differential equations.

Unit	Topics	N Le
I	TheGammaFunction:Analyticalcharacters.Euler'slimitformula.Duplicationformula.Eulerianintegraloffirst kind,Canonicalproduct.Asymptoticexpansion.Hankelcontourintegral.	
II	Hypergeometric Functions: Solution of homogeneous linear differential equation of order two. Second order differential equation with three regular singularities. Hypergeometric equation and its properties. Confluent hypergeometric equation.	
III	Legendre functions: Complete solution of Legendre's differential equation. Integral representations and recurrenceformulaefor$P_n(z)$,$Q_n(z)$.	
IV	Legendrepolynomialsoflargedegree.Neumann'sexpansiontheorem.Associated Legendre'sfunction.	

Course outcomes:
CO1: The students will be able toexplain the applications and the usefulness of special functions.
CO2: The students will be able to analyse properties of special functions.
CO3: The students will be able to understand Hankel contour integral, Hypergeometric equationsand its propertie
CO4: The students will be able to understand Legendre polynomials of large degree.
CO5:The students will be able to know Neumann expansion theorem.

Suggested readings:
1. E.T. Copson: Theory of Functions of a Complex Variable (Chapters IX and XIV).

M.A./M.Sc. II (SEMESTER-III) PAPER-IV
FUZZY SETS

Course Code: MMHE-504(g)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** FUZZY SETS	

Course objectives: The course aims to introduce students to fundamental concepts in fuzzy sets, fuzzy relations, arithmetic operations on fuzzy sets, possibility theory and its applications.

Unit	Topics	No. of Lectures
I	**Fuzzy Sets:** Basicdefinitions,α−levelsets.Convexfuzzysets.Basicoperationsonfuzzysets. Typesof fuzzysets.Cartesianproducts.Algebraicproducts. Boundedsumand difference,t−norms and t−conorms.	15
II	**TheExtensionPrinciple:** TheElementsofFuzzyarithmetic. Zadeh'sextensionprinciple.ImageandinverseimageofFuzzysets.Fuzzynumbers.	15
III	**Fuzzy Relations and Fuzzy Graphs:**Fuzzy relations on fuzzy sets. Composition of Fuzzy relations. Min−Max compositionand its properties. Fuzzy equivalence relations. Fuzzy compatibility relations. Fuzzy relation equations. Fuzzy Graphs.Similarityrelation.	15
IV	**Possibility Theory**:Fuzzy measures, Evidence theory, Necessity measure. Possibility measure. Possibility distribution, Possibilitytheory andFuzzy sets, Possibilitytheory versus probability theory.	15

Course outcomes:

CO1: Thestudents will be able todescribe and compute vague concepts using fuzzy sets.

CO2: The students will be able to construct fuzzy rules and define fuzzy measures on them.

CO3: The students will be able to design some common fuzzy systems and fuzzy controllers.

CO4: The students will be able to illustrate the organization, design, and operations of some common fuzzy systems.

Suggested readings:

1. Klir, G. J. and Bo Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India, New Delhi 1995
2. Zimmermann, H. J., Fuzzy Set Theory and Its Applications, Allied Publishers Ltd, New Delhi 1991
3. Ross, T. J., Fuzzy Logic with Engineering Applications, McGraw Hill Inc., New Delhi
4. Backzinski, M. and J Balasubramanian, Fuzzy Implications, Springer Verlag, Heidelberg 2008.

M.A./M.Sc. II (SEMESTER-III), PAPER-V

PROGRAMMING IN PYTHON-I

Course Code: MMHL-505	**Credits-4** **Marks: 25+75**	**Practical**
Total No. of Lectures-Practicals (in hours per week)– 4-2	**Course Title:** **PROGRAMMINGIN PYTHON-I**	

Course objectives: The course objective is to familiarize the students with features of Python as a programming tool. The course aims to give exposure to basic concepts of the Python programming.

Basics of Python programming

Introduction to numPy and Matplotlib package: History of Python Identifiers, Key words, Statements & Expressions, Variables, Operators, Keywords, Input-Output, Control Flow statements, Functions, Numerical problems on numPy.

1. Program to check whether the given number is odd or even.
2. Program to input two numbers and swap them.
3. Program to calculate factorial of a number.
4. Program to test the divisibility of a number with another number.
5. Program that reads three numbers and print them in ascending orders.
6. Program to print table of a number.
7. Program to print sum of natural number between any two positive number
8. Program to input a number and test if it is a prime number.
9. Program that searches for prime number from 15 through 25.
10. Program to input three numbers and display the largest/smallest number.
11. Program to print Fibonacci numbers.
12. Program to find the sum of the series: $1 + x + x^2 + \cdots + x^n$.
13. Program to find the sum of the series: $1 - x + x^2 - \cdots x^n$.
14. Program to convert binary number to decimal number and vice versa.
15. Program to find roots of quadratic equation.
16. Program to find sum and differences product of two matrices and hence find the row sum and column sum of a given matrix.
17. Program to find the transpose, trace and norm of a matrix.
18. Program to accept a matrix and determine whether it is a symmetric matrix/ skew-symmetric or not.

Course outcomes:

CO1: Thestudents will be able to describe the basic principles of Python programming language.
CO2: The students will be able to implement object-oriented concepts.
CO3: The students will be able to making use of software easily right out of the box.
CO4: The students will be able to experience with an interpreted language.

Suggested readings:

1. S. Gowrishankar and A. Veena A, Introduction to Python Programming, CRC Press (2019).
2. Adam Stewart -Python Programming (2016).
3. Kenneth A. Lambert, Fundamentals of Python First Programs with Mindtap, Cengage Learning India (2011).

M.A./M.Sc. II (SEMESTER-III), PAPER-VI

RESEARCH PROJECT

Course Code: MMHP-506	**Credits-4**	**Project**
	Course Title: RESEARCH PROJECT	

Course objectives: The objective to introduce research project is that the students are able to understand the nature of problem to be studied and identify the related area of knowledge, review literature to understand how others have approached or dealt with the problem.
Each student will do a Research project, under the guidance of a supervisor. There will be a seminar presentation, based on research project at the end of the semester. Evaluation of the research project will be done after the completion of fourth semester.
Course outcome: The students are able to do research problems**.**

M.A./M.Sc. II (SEMESTER-IV), PAPER-I

LEBESGUE INTEGRATION THEORY

Course Code: MMHC-511	
Total No. of Lectures (in hours per week) - 4	
Course objectives: Measure and integration theory generalizes the notion of integration. The main objective is to familiari	

Unit	
I	**Lebesgue integral of simple measurable functions and convergence theorems:** LebesgueInte ,anditsproperties.Boundedconvergencetheorem, LebesgueintegrationandRiemannintegration. Integrationon
II	**Lebesgue integral o** Integrationofanon−negativemeasurablefunctiononameasurespace,Lebesgueintegralofgeneralmeasurablefun functions. Integral as a countably additive set function. Integral of a non−negative function o Fatou'slemma,Lebesgue'sdominated convergencetheorem.
III	**Product measure and L_p -space:** Extension of a measure on an algebra to an outer measure, Pro ,Measurabilityofasectionof measurable setwithfiniteproductmeasure,Fubini'stheorem, L_p Spaces: L_p (X, M, μ) and L_p(X, M, μ) spaces as vector spaces, Norm on L_p (X, M, μ) spaces, Holder's a
IV	**Differentiation:** Dini's four derivatives, Differentiation of monotonic functions, Inte function.Derivativeofanintegral,FundamentaltheoremoftheIntegralCalculusfor theLebesgue integration.

Course outcomes:

CO1: The students will be able to compute Riemann as well as Lebesgue integration and differentiate both the int
CO2: The students will be able to derive convergence theorems and their application.
CO3: The students will be able to learn L_p -spaces and its characteristics. **CO4**: The students will be able to know

Suggested Readings:

1. W.Rudin, Principles of Mathematical Analysis, McGraw Hill, 1983.

2. H.L.Royden, RealAnalysis,MacmillanPub.Co.Inc.NewYork,4th Edition,1993.
3. G.deBarra, MeasuretheoryandIntegration,WileyEasternLimited,1981.
4. Frank Burk, Lebesgue Measure and Integration: An Introduction, John Wiley & Sons, 1997.

M.A./M.Sc. II (SEMESTER-IV) PAPER-II

HILBERT SPACES

Course Code: MMHC-512	**Credits-4** **Marks: 25+75**	**Core paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** **HILBERT SPACES**	

Course objectives: To familiarize with the basic tools of Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another.

Unit	Topics	No. of Lectures
I	Inner product spaces, their basic properties and examples, Schwartz inequality, Norm induced by inner product,Continuity of inner product,Parallelogram equality, polarization identity, Characterization of inner product in terms of norm, Hilbert spaces and their examples.	15
II	Orthogonal vectors**,** Orthogonal Complement**,** Orthogonal sum, Projection Theorem, Orthogonal Projection operator and its properties, Orthogonal sets and their advantage over its linearly independent sets. Complete orthonormal sets, Bessel's generalized inequality, Parseval's Relation, Fourier series representation.	15
III	BoundedlinearfunctionalsonHilbertspaces,Riesz−Frechetrepresentationtheorem. Dualspaces, Innerproduct structureofdualspaces,ReflexivityofHilbertspaces.	15
IV	Hilbert adjoint operators, Shift operators, Special cases of Hilbert adjoint operators, self-adjoint operators, positive operators, normal operators, unitary operators. Orthogonal projection operators**,**Eigenvalues and Eigen Vectors of an Operator, Spectrum of an operator, The Spectral Theorem on a Finite-Dimensional Hilbert Space.	15

Course outcomes:

CO1: It provides an impressive illustration of the unifying power of functional analytic methods in linear algebra, linear ordinary and partial differential equations, calculus of variations, approximation theory and linear Integral equations.

CO2: The students will be able to classify the functional analytic methods and results in various field of mathematics and its applications.

CO3: The students will be able to know the importance of Riesz−Frechetrepresentationtheorem.

Suggested Readings:

1. E. Kreyszig: Introductory Functional Analysis with Applications, John Willey & sons, New York, 1978.
2. W. Rudin: Functional Analysis, Tata Mc Graw- Hill, New Delhi, 1977.
3. P.K.Jain,O.P.AhujaandK.Ahmad:FunctionalAnalysis,NewAgeInternational(P)Ltd.andWileyEasternLtd.,New Delhi,1997.
4. F. B. Choudhary & S. Nanda: Functional Analysis with Applications, Wiley Eastern Ltd., 1989.
5. I.J Maddox: Functional Analysis, Cambridge University Press,1970.
6. G.F.Simmons:IntroductiontoTopologyandModernAnalysis,McGraw−HillBookCompany,NewYork,1963.
7. K.ChandrashekharaRao: FunctionalAnalysis,NarosaPublishingHouse,NewDelhi.

M.A./M.Sc. II (SEMESTER-IV), PAPER-III

CONTINUUM MECHANICS

Course Code: MMHE-513(a)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: CONTINUUM MECHANICS**	

Course objectives: The course of continuum mechanics aims todevelop understanding of the common mathematical foundation to describe the behaviour of matter. The course introduces continuum hypothesis, deformation, stress and strain tensors and fundamental physical laws.

Unit	Topics	No. of Lectures
I	**Tensor Analysis**: Summation convention and indicial notation, coordinate transformation, contravariant, covariant and mixed tensors, Algebra of tensors, Contraction theorem, Quotient law, Isotropic tensors, Tensor as operator, Symmetric and skew-symmetric tensors, Deviatoric Tensors. Scalar, vector and tensor functions, comma notation, Gradient of vector functions, Divergence and Curl of tensor functions, Laplacian operator in tensor form, Integral theorems for tensors: Gauss divergence, Stokes and Green's theorems.	15
II	**Continuum Hypothesis and Deformations:** Continuum Hypothesis, Configuration of a continuum, Mass and density, Description of motion, Material and spatial coordinates, Translation, Rotation, Deformation of a surface element, Deformation of a volume element, Isochoric deformation, Stretch and Rotation, Decomposition of a deformation, Deformation gradient, Strain tensors, Infinitesimal strain, Compatibility relations, Principal strains.	15
III	**Stress tensor and Stress-Strain relation:** Material and Local time derivatives Strain, rate tensor, Transport formulas, Stream lines, Path lines, Vorticity and Circulation, Stress components and Stress tensors, Normal and shear stresses, Principal stresses.	15

IV	**Fundamental Physical Laws**: Law of conservation of mass, Law of conservation of linear and angular momentum, Law of conservation of energy and their representing equations in material and spatial forms.	15

Course outcomes:

CO1: The students will be able todefine continuum hypothesis and deformation.

CO2: The students will be able to explain that how stress-strain are related.

CO3: The students will havedeep knowledge of fundamental physical laws.

Suggested readings:

1. D. S. Chandrasekharaiah and L. Debnath, "Continuum Mechanics", Academic Press, 1994.
2. A. J. M. Spencer, "Continuum Mechanics", Dover Publication Inc., New York, 1980.
3. Y. C. Fung, "A First course in Continuum Mechanics", Prentice Hall, 1977.
4. P. Chadwick, "Continuum Mechanics", Dover Publication Inc., New York, 1976.
5. A. I. Borisenko, "Vector and Tensor Analysis with Applications", Dover Publications, 2003.
6. R. S. Mishra, "A Course in Tensors with Applications to Riemannian Geometry", Pothishala Private Ltd., 1965.
7. P. Grinfeld, "Introduction to Tensor Analysis and the Calculus of Moving Surfaces", Springer, 2013.

M.A./M.Sc. II (SEMESTER-IV) PAPER-III

THEORY OF SUMMABILITY

Course Code: MMHE-513(b)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: THEORY OF SUMMABILITY**	

Course Objectives: The course aims to introduce some special methods of summation, different types of means, some simple theorems concerning Cesarosummability and Abel summabilty. We also study matrix summabilty and multiplication of series.

Unit	Topics	No. of Lectures
I	Special method of summation. Norlund means. Regularity and consistency of Norlund means. Inclusion. Equivalence.	15
II	Arithmetic means, Holder's means, Simple theorems concerning Holder's means,Cesaro means. Means of non−integral orders.	15

III	Simple theorems concerning Cesarosummability. Equivalence theorem. Cesaro and Abel summability (theorems 63, 64, 65 and 66 from Hardy's 'Divergent series').	15
IV	Matrix summability: Ordinary summability of sequences by infinite matrices (Treatment of the above to followed from Maddox's book).Multiplication of series: Multiplication of (C,K) summable series.	15

Course outcomes:

CO1: Students will be able tounderstand Norlund means, Arithmetic means, Holder's means etc.

CO2: Students will be able tounderstand Cesaro and Abel summability.

Suggested readings:

1. G.H. Hardy: Divergent series, Oxford, 1949.
2. E.C.Titchmarsh:TheoryofFunctions(relevantportionofchapterXIII).
3. Zygmud:TrigonometricseriesVol.f,Cambridge,1959(relevantportionofchapterXIII).
4. I.J.Maddox:ElementsofFunctiona lAnalysis,CambridgeUniversityPress,1970(relevantportionofchapter7).

M.A./M.Sc. II (SEMESTER-IV) PAPER-III

OPERATIONS RESEARCH

Course Code: MMHE-513(c)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** OPERATIONS RESEARCH	

Course Objectives: This course develops the ideas underlying the input-output analysis, Inventory control, s problems and Queuing theory.

Unit	Topics
I	**Input-OutputAnalysis**:Introduction,meaningofinput-output,Mainfeaturesofanalysisandassumptions,Leontief staticmodel,Input-outputtable,Balanceequation,Inter-industrialrelation,Technologicalcoefficient,Technology matrix,Problembasedonchangingdemands.
II	**Inventory control:** Introduction, Classification of inventory. Economic parameters associated with inventory problems, Deterministicmodels,Economiclotsizemodelwithuniformrateofdemand,Sensitivityanalysisofeconomicorder quantityformula,Economiclot sizewithdifferentrateofdemandindifferentcycles,Economiclotsizewithfiniterateof production,LimitationofEOQformula,Deterministicmodelwithshortage, Instantaneousproductionwithbackorders, Finiterateofreplenishmentofinventory,Fixedtimemodel,Lost–sales,shortages,Multi–itemdeterministicmodelwith onelinearconstraint, Restrictiononthenumberofstockedunits,Restrictionontheamounttobeinvestedoninventory,Models with leadtime.

III	**Problemsofreplacement:**Introduction,Replacementmodelsandtheir solutions, Concept of present value, Replacementofitemswhoseefficiencydeteriorateswithtime,Replacementofitemswhosemaintenancecostincreases withtimeandthevalueofmoneyremainsconstant,Replacementofitemswhenthevalueofmoneyalsochanges, Criteriaofpresentvalueforcomparingreplacementalternative,Staffingproblem.**SequencingProblems**: Assumptionsforsequencingproblem,Processingnjobsontwomachines,njobsonthree machines,2jobsonmmachines.
IV	**Queuing Theory:**Queuing models, Probability Distribution of Arrival and Service Times, Pure birth death process, M/M/1, M/M/c queuing models,Steady state and transient probabilities of models,Waiting time distribution, M/G/1, G/M/1, M/D/C queuing models.

Course outcomes:

CO1: The **s**tudents will be able toexplain meaning of out-output, Leontief static model, Inter-industrial relation a related concepts.
CO2: The students will be able classify inventory and also able to define various type of models
CO3: The students will be able todefine various replacement models and find their solutions.
CO4: The students will be able solve sequencing problems.
CO5: The students will be able to define various queuing models.

Suggested readings:

1. Bazaraa, Mokhtar S., Jarvis, John J., &Sherali, Hanif D. (2010). Linear Programming and Network Flow ed.). John Wiley and Sons.
2. Hadley, G. (1997). Linear Programming. Narosa Publishing House. New Delhi.
3. Taha, Hamdy A. (2010). Operations Research: An Introduction (9th ed.). Pearson.
4. M. S. Bazaraa, H. D. Sherali and C. M. Shetty. Nonlinear Programming Theory and Algorithms,Wiley.
5. Kanti Swarup, P.K.Gupta& Man Mohan: Operations Research, S. Chand.
6. S.D.Sharma: Operations Research (2012), Kedar Nath.

M.A./M.Sc. II (SEMESTER-IV), PAPER-III

FINSLER GEOMETRY

Course Code: MMHE-513(d)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** **FINSLER GEOMETRY**	
Course objectives: This course introduces the notion of Finsler Geometry as a generalization of Riemannian geometry. The main objective of it is to introduce the students the fundamental postulates of Cartan, geometry of paths and motion in Finsler spaces.		

Unit	Topics	No. of Lectures
I	Finsler metricfunction,itsproperties,Tangentspace.Indicatrix.MetrictensorandC−tensorHomogeneity, propertiesofg_{ij}andC_{ijk},Dualtangentspace.Geodesics.	15

II	δ −differentiation,Partialδ−differentiation.Propertiesofpartial δ−differentiation. Fundamental postulates of Cartan,Cartan's covariant derivatives and their properties.	15
III	Geometry of paths, Berwald's covariant derivative and its properties, Curvature tensor of Berwald, Commutationformularesultingfrompartialδ−differentiation,Othercommutationformulae.	15
IV	Threecurvature tensorsofCartan,IdentitiessatisfiedbycurvaturetensorsincludingBianchiidentities, Lie derivatives in Finsler Spaces, Motion in Finsler Spaces.	15

Course outcomes:
CO1: The students will be able todefine Finsler spaces.
CO2: The students will be able to describe fundamental postulates of Cartan.
CO3: The students will be able to derive commutationformularesultingfrompartialδ−differentiation.

Suggested Readings:
1. H. Rund: The Differential Geometry of Finsler Spaces, Springer−Verlag, 1959.
2.M.Matsumoto:FoundationsofFinslerGeometryandspecialFinslerspaces,KaiseishaPress,Saikawa,Otsu,520Japan, 1986.

M.A./M.Sc. II (SEMESTER-IV) PAPER-III
COSMOLOGY

Course Code: MMHE-513(e)	**Credits-4** **Marks: 25+75**	**Elective pape**
Total No. of Lectures (in hours per week) - 4	**Course Title: COSMOLOGY**	

Course objectives: This course aims to introduce static and non-static cosmological model Einsteinandde-sitterUniverse,Originand Evolutionof Universe, Big-bang theory, c-field theory and steady state theory.

Unit	Topics
I	Conservation of electric charge, Transformation formula for the densities of electric charge and electric curren Maxwell'sequationinvacuo,Propagationofelectricandmagneticdensities,Transformationequationfordifferential operator, Lorentz invariance of Maxwell's equations, Maxwell's equation in tensor form, Lorentz force c acharged particle,Lorentzforcedensity,energymomentumtensorforelectromagneticfield,ElectromagnetismimGeneralRelativ Derivation of Einstein−Maxwell's Equations from action principle, Reissner− Nordstrom Solution, The Tolman Metri

II	Static cosmological models, Properties of Einstein Universe, Properties of de−Sitter Universe, Difference betw Einsteinandde−sitterUniverse,Non-Staticcosmologicalmodels,DerivationofRobertson−Walkermetric,Geometrical features of R−W metric, Observable parameters in Robertson−Walker metric, Friedmann−Robertson−Wa cosmological models, Particles Horizon, Event Horizon, Einstein's field equation and dynamics of the univ Cosmologies with a non- zero.
III	OriginandEvolutionofUniverse,Creationofmatter,C−fieldTheory(Hoyle-Narlikartheory),Theactionprinciple, Cosmologicalequations,explosiveCreation,Thelargenumberhypothesis,ObservableparametersoftheSteadyState Theory. Differentialform,Connection1-formandRicciRotationCoefficient,Cartan'sequationsofstructure,Bianchiidentities symmetry properties of the Riemann−Christoffel Tensor, Calculation of Riemann Christoffel Tensor.
IV	Gravitational Collapse, Gravitational Collapse of a Homogeneous Dust ball, Black Holes (Strong Gravitational fiel Non−sphericalGravitationalCollapse,Pricetheoremanditsimplications,TheKerrmetricortheRotatingblackHoles,Kerr−Newmanmetric,ThelawsofBlackHoleThermodynamics.

Course outcomes:

CO1: The students will be able to define various types of cosmological models.

CO2: The students will be able to differentiate between Einstein universe and De-sitter universe.

CO3: The students will be able toexplain geometrical features of R-W metric, Big-bang theory, c-field theory theory.

CO4: The students will be able to define cosmological equations.

Suggested readings:

1. K. D. Krori: Fundamentals of Special and General Relativity; PHI Publication, 2010.
2. S.R.RoyandRajBali:TheoryofRelativity;JaipurPublishingHouse,2008.
3. Steven Weinberg: Gravitation and Cosmology: Principles and applications of General Relativity; Wiley Public
4. J.V.Narlikar:AnIntroductionstoRelativity;CambridgeUniversityPress,2010.
5. I.B. Khriplovich: General Relativity; Springer Science + business media, 2005.

M.A./M.Sc. II (SEMESTER-IV) PAPER-III

APPLICATION OF MATHEMATICS IN FINANCE

Course Code: MMHE-513(f)	**Credits-4** **Marks: 25+75**	**Elective pa**
Total No. of Lectures (in hours per week) - 4	**Course Title:** APPLICATION OF MATHEMATICS I	

Course objectives: This course introduces the basic concepts of Financial Management such as Insurance and Measuremen under uncertainty situations. The philosophy of this course is that Time value of Money - Interest rate and discount rate pla role in Life Insurance.

Unit	Topics
I	**FinancialManagement**:Anoverview.Natureandscopeoffinancialmanagement.Goalsoffinancialmanageme maindecisionoffinancialmanagement.Differencebetweenrisk,speculationandgambling.
II	**TimeValueofMoney**:Interestrateanddiscountrate,Presentvalue and future value−discrete case as ascontinuous compounding case, Annuities and its kinds. Meaning of returns:ReturnasInternalRateofReturn(IRR),NumericalmethodslikeNewton−Raphsonmet calculateIRR,Measurementofreturnsunderuncertaintysituations.
III	Meaningofrisk:Differencebetweenriskanduncertainty.Typesofrisks.Measurementofrisk.Calculationofsecurity andPortfolioRiskandReturn−MorkowitzOmdel.Sharpe'sSingleIndexModel−SystematicriskandUnsystematicRisk. TaylorSeriesandBondValuation.Valuation.CalculationofDurationandConvexityofBonds.
IV	FinancialDerivative:Futures.Forwards.SwapsandOptions.CallandPutOption.CallandPutParitytheorem.Pricingof contingentclaimsthroughArbitrageandArbitragetheorem. Pricing by Arbitrage: A Single Period Option Pricing Model. Multi Period Pricing Model−Cox−Ross−Rubins Model. Bounds on Option Prices.

Course outcomes:

CO1: The students will be able tolearn the basics of Financial Management.
CO2: The students will be able to learn Time value of money.
CO3: The students will be able to understand the meaning of risk and financial derivatives.

Suggested readings:

1. AswathDamodaran:CorporateFinance-TheoryandPractice,JohnWiley&Sons,Inc.
2. JohnC.Hull:Options,FuturesandOtherDerivatives,Prentice−HallofIndiaPvt.Limited.
3. SheldomM.Ross:AnIntroductiontoMathematicalFinance,CambridgeUniversityPress.
4. SalihN.Neftci:AnIntroductiontoMathematicsofFinancialDerivatives,AcademicPressInc.
5. RobertJ.ElliottandP.EkkehardKopp:MathematicsofFinancialMarkets,Springer−Verlag,NewYorkInc.

M.A./M.Sc. II (SEMESTER-IV) PAPER-III

HISTORY OF MATHEMATICS

Course Code: MMHE-513(g)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: HISTORY OF MATHEMATICS**	

Course objective: The main objective of this course is to introduce the developments in the theory of mathematics from ancient to modern times.

Unit	Topics	No. of Lectures

I	Ancient Mathematics: The Babylonians. The Egyptians. The Greeks. The Romans, The Maya, The Chinese, The Japanese. The Hindus. The Arabs.	15
II	Mathematics in Europe during the middle age.	15
III	Mathematics during the sixteenth, seventeenth, eighteenth, nineteenth, and twentieth centuries.	15
IV	There naissance Vieta and Descartes to Newton, Euler, Lagrange, Laplace, Hardy, and Ramanujan.	15

Course outcomes:

CO1: The students will be able to know ancients mathematics, middle age mathematics and modern mathematics.

CO1: The students will be able to know that how the concepts have been developed in Mathematics.

Suggested Readings:

1. F. Cajon: A History of Mathematics, 1894.
2. J. Stillwell: Mathematics and its History, Springer International Edition, 4th Indian Reprint, 2005.

M.A./M.Sc. II (SEMESTER-IV) PAPER-IV

MAGNETOHYDRODYNAMICS

Course Code: MMHE-514(a)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: MAGNETOHYDRODYNAMICS**	

Course Objectives:

- To introduce the various laws of electromagnetism and derive their representing equations.
- To examine electromagnetic waves in various types of electrically conducting fluids.
- To discuss the magnetostatics and its applications
- To describe the boundary conditions in electromagnetic field and study the hydromagnetic flows in various geometries with different conditions.

Unit	Topics	No. of Lectures
I	**entals of Magnetohydrodynamics (MHD):** Basic concepts ofMagnetohydrodynamics and its applications, MHD approximations, Maxwell's relations, Electrostatics: Coulombs law, Gauss law, Dielectric material, Electrodynamics: Faraday's law, Conservation of charges, Ampere's law, Solenoidal relation, Ohm's law.	15
II	**atic Aspect of MHD:** Lorentz force, Magnetic Induction equation, Alfven theorem, Frozen-field-phenomenon, Analogue of Helmholtz vorticity equation in MHD, Bernoulli's equation in MHD, Ferraro's law of	15

	assortation, Electromagnetic boundary conditions, non-dimensional numbers.	
III	**tohydrodynamicWaves:**Alfven waves, Alfven waves in incompressible fluids, Walen's equation, equipartition of energy, Alfven waves in compressible fluids, Transverse and Magneto-Acoustic Waves. **tostatics:**Magnetostatics: Force free magnetic field, Equations of force free magnetic field, Chandrasekhar's theorem, Applications of magnetostatics, Pinch effect, Instability of Bennett Pinch.	15
IV	**tohydrodynamic flows:** One dimensional MHD flows: Hartmann flow, Couette flow, MHD Stokes flow, Temperature distribution in Hartmann flow, Two dimensional MHD flow: Aligned flow.	15

Course outcomes:

CO1: The **s**tudents will be able tounderstand various laws of electromagnetism and their consequences.

CO2: The students will be able to examine the electromagnetic waves and its effects on the flow system.

CO3: The students will be able toexplore the force field, magnetic field and its significances.

CO4: The students will be able to develop the flow models for hydromagnetic flows appearing is various biosciences, engineering and technological applications.

Suggested readings:

1. T. G. Cowling, "Magnetohydrodynamics", Interscience Publishers, Inc., New York, (1958).
2. Allen Jeffrey, "Magnetohydrodynamics", Oiver& Boyd, New York, (1966).
3.K. R. Cramer and S. I. Pai, "Magnetofluid Dynamics for Engineers and Physicists", McGraw-Hill Book Company, New York, (1973).
4.G. W. Sutton and A. Sherman, "Engineering Magnetohydrodynamics", Dover Publication Inc., New York, (1965).
5.P. A. Davidson, "An Introduction to Magnetohydrodynamics", Cambridge University Press, New York, (2010).

M.A./M.Sc. II (SEMESTER-IV) PAPER-IV

MATHEMATICAL MODELLING

Course Code: MMHE-514(b)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: MATHEMATICAL MODELLING**	

Course objectives: The objectives of this course are to:

- Enable students understand how mathematical models are formulated, solved and interpreted.
- Make students appreciate the power and limitations of mathematics in solving practical real-life problems.
- Equip students with the basic mathematical modelling skills.

Unit	Topics	No. of Lectures

I	**Mathematical Modelling:** Need, technique, classification, and simple illustration of mathematical modelling Limitations of mathematical modelling. **Mathematical Modelling Through Ordinary Differential Equations of First Order:** Linear and Non-linear Growth and Decay models, Compartment models. Mathematical modelling of geometrical problems through ordinary differential equations of first order.	15
II	**Mathematical Modelling Through System of Ordinary Differential Equations of First Order:**Mathematical modelling in Population Dynamics. Mathematical modelling of epidemics. Compartment models. Mathematical modelling in Economics. Mathematical models in Medicine. Arm Race, Battles and International Trade in terms of system of ordinary differential equations.	15
III	**Mathematical Modelling Through Ordinary Differential Equations of Second Order:**Mathematical modelling of planetary motions. Circular motion and motion of satellites. Mathematical modelling through linear differential equations of second order, Application of Differential Equation in Cardiography.	15
IV	**Mathematical modelling through partial differential equations:**Situations giving rise to of partial differential equation models. The transmission Line Application of partial Differential Equation in Nuclear reactors.	15

Course outcomes:

CO1: The students will be able toconvert a real-world problem into a mathematical model.
CO2: The students will be able to do mathematical modelling through ordinary differential equations of first order and second order.
CO3: The students will be able to do mathematical modelling through partial differential equations.

Suggested readings:

1. J. N. Kapur: Mathematical Modelling, New age International (P) Limited, New Delhi.
2. Zafar Ahsan: Differential Equations and Their Applications, PHI learning Private Limited, New Delhi.

M.A./M.Sc. II (SEMESTER-IV), PAPER-IV

WAVELET THEORY

Course Code: MMHE-514(c)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title: WAVELET THEORY**	

Course objectives: The course aim is to introduce a flexible system which provide stable reconstruction and analysis of functions (signals) and the construction of variety of orthonormal bases by applying operators on a single wavelet function.

Unit	Topics	No. of Lectures
I	Basic Fourier Analysis: Fourier transform of square integrable functions, Plancheral formula, Poisson Summation formula, Shannon sampling theorem, Heisenberg Uncertainty principle.	15
II	Continuous Wavelet transform, Plancherel formula, Inversion formulas. Frames, Riesz Systems, discrete wavelet transform.	15
III	Orthogonal bases of wavelets, multi resolution analysis, smoothness of wavelets, compactly supported wavelets, construction of compactly supported wavelets.	15
IV	Franklin wavelets and Spline wavelets on Real line. Orthonormal bases of periodic splines. Characterization of MRA wavelets, low-pass filters and scaling functions.	15

Course outcomes:
CO1: The students will be able to understand approximation of functions (signal).
CO2: The students will be able to explain the applications of wavelets in the construction of orthonormal bases by wavelets.

Suggested Readings:
.1. E. Harnandez and G. Veiss: A first course of wavelets, CRC Press New York, 1996.
2. C.K. Chui: An Introduction to wavelets, Academic Press, 1992.
3. I. Daubechies: Ten lectures on Wavelets, CB5-NSF Regional Conference in Applied Mathematics, 61, SIAM, 1992.

M.A./M.Sc. II (SEMESTER-IV), PAPER-IV
STRUCTURESONADIFFERENTIABLEMANIFOLD

Course Code: MMHE-514(d)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** **STRUCTURESONADIFFERENTIABLEMANIFOLD**	

Course objectives: The objective of the course is to introduce a thorough understanding of the geometry and topology of manifolds and describe the structures on manifolds, such as vector bundles, vector fields and derivatives.

Unit	Topics	No. of Lectures
I	Almost complex Manifolds, Nijenhuis tensor, Eigen-values of F, Contravariant and covariant analytic vectors, F−connection.	15
II	**Almost Hermite Manifolds**: Definition, almost analytic vector fields, Curvature tensor, Linear connections.	15

III	**Kähler Manifolds**: Definition, Curvature tensor, Affine connection, Properties of projective, conformal, concircular and conharmonic curvature tensors. Contravariant almost analytic vector.	15
IV	Almost contact manifold, Lie derivative, Affinely almost co-symptectic manifold, Almost Grayan manifolds, Particular affine connections.	15

Course outcomes:

CO1: The students will be able to define F-connection.

CO2: The students will be able to explain Almost Hermite manifolds.

CO3: The students will be able to explain Kähler Manifolds and almost Kähler Manifolds.

Suggested readings:

1. R.S. Mishra: Structures on differentiable manifold and their applications, ChandramaPrakashan, Allahabad, 1984.

2. K. Yano and M. Kon: Structure of Manifolds, World Scientific Publishing Co. Pvt. Ltd., 1984.

M.A./M.Sc. II (SEMESTER-IV) PAPER-IV

SPHERICAL ASTRONOMY-II

Course Code: MMHE-514(e)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** SPHERICAL ASTRONOMY-II	

Course objectives: The objective of this course is to introduce planetary phenomena like geocentric motion, elongation o lunar and solar eclipses and much more. The course also introduces positional astronomy like determination of longitude a sextant, dip of the horizon.

Unit	Topics
I	Planetary phenomena, geocentric motion of a planet, elongation, stationary points, phases, brightness of theLunar and solar eclipses.
II	Earth's shadow at moon's distance, ecliptic limits, greatest and least number of eclipses in a year.
III	Determinationoflongitudeandlatitude,sextant,dipofthehorizon,Mercator'sprojection,greatcircleonMercator's chart, positioncircle.
IV	Propermotionsanditseffectinrightascensionanddeclination,positionangle,changeinpositionangleduetostar's motionandduetothemotionof thepole,themotionofthesun,parallacticmotioninrightascensionand declination, Binaries.

Course outcomes:

CO1: The students will be able to know brightness of the lunar and solar eclipses.

CO2: The students will be able to know the greatest and least number of eclipses in a year.

CO3: The students will be able to determine the longitude and latitude.

Suggested readings:

1. Gorakh Prasad: A Text book on Spherical Astronomy, Pothishala (Pvt.) Ltd.
2. Ball: A Text book of Spherical Astronomy.

M.A./M.Sc. II (SEMESTER-IV) PAPER-IV

SPECIAL FUNCTIONS-II

Course Code: MMHE-514(f)	**Credits-4** **Marks: 25+75**	**Elective paper**
Total No. of Lectures (in hours per week) - 4	**Course Title:** SPECIAL FUNCTIONS-II	

Course objectives: This course aims to introduce Bessel function, Hankel function, elliptic fu Weierstrass,Weierstrass'ssigmafunctions andZetafunction of complex variables.

How to insetUnit	Topics
I	Bessel's differential equation and its series solution. Recurrence formula for $J\mu(z)$,Schlaffi's contour integral fo $J\mu(z)$,Besselfunctionforintegralorder.Generatingfunctionfor $J\mu(z)$,SolutionofBessel'sequationbycomplexintegra Hankel'sfunctions.
II	ConnectionbetweenBesselandHankelfunctions,ThecompletesolutionofBessel'sequation,Neumann'spolynomials and Neumann's expansion theorem.
III	The elliptic functions of Weierstrass: Periodic functions, Lower bound of the period of an analytic function, Definitionofanellipticfunction,Theirreduciblepolesandzerosofanellipticfunctionandproperties.
IV	Weierstrass'ssigmafunctions,Zetafunction,Weierstrass'sellipticfunctionsandtheirproperties.

Course outcomes:

CO1: Thestudents will be able todefine Bessel's differential equation and its series solution, Recurrence formu and generating function for $J_n(z)$.

CO2: Thestudents will be able toexplain connection between Bessel and Hankel function and complete solution equation.

CO3: Thestudents will be able to define elliptic functions of Weierstrass, Periodic function, the irreducible pole of an elliptic function and their properties.

Suggested readings:

1. E.T. Copson: Theory of Functions of a Complex Variable (Chapters IX and XIV).

M.A./M.Sc. II (SEMESTER-IV) PAPER-IV

FUZZY LOGIC

Course Code: MMHE-514(g)	**Credits-4** **Marks: 25+75**
Total No. of Lectures (in hours per week) - 4	**Course**

Course objectives: This course is designed to solve problems by considering all available information and making the bes

Unit	Topics
I	**FuzzyLogic**:Anoverviewofclassicallogic,Multivaluedlogics.Fuzzypropositions.Fuzzyquantifiers.Linguisticvaria andhedges.Inferencefromconditionalfuzzypropositions,thecompositionalruleofinference.
II	**ApproximateReasoning:**Anoverviewoffuzzyexpertsystem.Fuzzyimplicationsandtheirselection.Multiconditionala
III	**An Introduction to fuzzy Control**: Fuzzy controllers. Fuzzy rule base. Fuzzy inference engine. Fuzzif (the center of area, the center of maxima, and the mean of maxima methods).
IV	**DecisionMakinginfuzzyEnvironment:**Individualdecisionmaking,Multi-persondecisionmaking,Multi-criteriad stagedecisionmaking.Fuzzyrankingmethods,Fuzzylinearprogramming.

Course outcomes:

CO1: The students will be able toinfer from conditional fuzzy propositions.

CO2: The students will be clear understanding of approximate reasoning.

CO3: The students will be able to know fuzzification and various defuzzification methods.

CO4: The students will have ability of decision making in fuzzy environment.

Suggested readings:

1. Klir, G. J. and Bo Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India, New Delhi 1995
2. Zimmermann, H. J., Fuzzy Set Theory and Its Applications, Allied Publishers Ltd, New Delhi 1991.

M.A./M.Sc. II (SEMESTER-IV), PAPER-V

PROGRAMMING IN PYTHON-II

Course Code: MMHL-515	**Credits-4** **Marks: 25+75**	**Practical**
Total No. of Lectures-Practicals (in hours per week) – 4-4	**Course Title:** **PROGRAMMINGIN PYTHON-II**	

Course objectives: The course objective is to familiarize the students with problem solving using Python programming. The course aims to design the Python programs for plotting of curves, solution of partial differential equations and plotting of their solution curves, graphic representations of data, like bar chart, pie chart, histogram andvarious computational methods.

Practicals:

1. Plotting one or multiple Curve (Cartesian, Polar and Parametric).
2. Plotting Curve from Data.
3. Plotting Points.
4. Plotting Bar Chart.
5. Plotting Pie Chart.
6. Plotting Histogram.
7. Linear Regression.
8. Solution of simultaneous equations by
   I. Matrix Inversion

II. Cramer's Rule
III. Gauss Elimination
IV. Gauss Jordan
V. Jacobi Iterative
VI. Gauss Seidel

9. Solving Ordinary and Partial differential equations and plotting the solution as curve or surface.

10. Find the root of algebraic/transcendental equation by using

I. Fixed point iterative method
II. Bisection's Method
III. Newton Raphson's Method
IV. Secant Method
V. Muller's Method
VI. Regula Falsi Method

Course outcomes:

CO1: The students will be able toanalyze the data by plotting Bar chart/Pie chart/Histogram using Python programming.

CO2: The students will be able to solve simultaneous equations by using Python Programming.

CO3: The students will be able to solve ordinary and partial differential equations by using Python Programming.

CO4: The students will be able to find roots of equations by using different methods with python programming.

Suggested readings:

1. S. Gowrishankar and A. Veena A, Introduction to Python Programming, CRC Press (2019).
2. Adam Stewart -Python Programming (2016).
3. Kenneth A. Lambert, Fundamentals of Python First Programs with Mindtap, Cengage Learning India (2011).

M.A./M.Sc. I (SEMESTER-IV), PAPER-VI

RESEARCH PROJECT/DISSERTATION

Course Code: MMHP-516	**Credit-4** **Marks-100**	**Project**
	Course Title: RESEARCHPROJECT/ DISSERTATION	

Course objectives: The objective to introduce research project is that the students are able to understand the nature of problem to be studied and identify the related area of knowledge, review literature to understand how others have approached or dealt with the problem.

Evaluation of the research project will be done upon completion of the fourth semester.

Course outcome: The students are able to do research problems**.**

Suggested equivalent online courses:

1. Swayam - https://www.swayam.gov.in/explorer?category=Math_and_Sciences
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. MIT Open Course Ware - Massachusetts Institute of Technology,https://ocw.mit.edu/courses/mathematics/
4. Coursera, https://www.coursera.org/courses?query=mathematics
5. edX, https://www.edx.org/course/subject/math

Further Suggestions:

Students and Faculty should be updated themselves by current knowledge of subjects and related course through digital resources, Journals and textbooks.

Any remarks/ suggestions:

The course contentcan be modified by BOS successively catering to the need of university.