PUNJABI UNIVERSITY, PATIALA

OUTLINES OF TESTS,

SYLLABI AND COURSES OF READING

FOR

M.Sc. (Mathematics)-I

2022-2023 & 2023-2024

Head
Mathematics Deptt.
Punjabi University, Patiala

CBCS

SEMESTER-1

CORE SUBJECTS

Code	Title of Paper/Subject	Hrs/Week	Credit	Max Cont. Assmt.	Marks Univ Exam	Total
MATM1101T	Algebra-I	6	6	30	70	100
MATM1102T	Mathematical Analysis	6	6	30	70	100
MATM1103T	Topology-I	6	6	30	70	100
MATM1104T	Differential Geometry	6	6	30	70	100

ELECTIVE SUBJECTS (Select any One)

Code	Title of Paper/Subject	Hrs/Week	Credit	Max Cont. Assmt.	Marks Univ Exam	Total
MATM1105T	Introduction to Computer and Programming using C	6	6	10	40	50
MATM1105L	Software Laboratory–I (C-Programming)	4	2	20	30	50
MATM1106T	Mathematical Statistics	6	6	30	70	100
MATM1107T	Linear Programming	6	6	30	70	100

for Head
Mathematics Deptt.
Punjabi University, Patiala

SEMESTER-II

CORE SUBJECTS

Code	Title of Paper/Subject	Hrs/Week	Credit	Max Cont. Asmt.	Marks Univ Exam	Total
MATM1201T	Algebra- II (Rings and Modules)	6	6	30	70	100
MATM1202T	Topology-II	6	6	30	70	100
MATM1203T	Differential Equations-I	6	6	30	70	100
MATM1204T	Complex Analysis	6	6	30	70	100

ELECTIVE SUBJECTS (Select any One)

Code	Title of Paper/Subject	Hrs/Week	Credit	Max Cont. Asmt.	Marks Univ Exam	Total
MATM1205T	Programming Using Python	6	6	10	40	50
MATM1205L	Software Lab–II (Python Programming)	4	2	20	30	50
MATM1206T	Functional Analysis	6	6	30	70	100
MATM1207T	Classical Mechanics	6	6	30	70	100

Open Elective (For Post Graduate Students) Basic Calculus (QUALIFYING PAPER)

For Other Department Students

Noohmad Singh

for Head
Mathematics Deptt.
Punjabi University, Patiala

MATM1101T: ALGEBRA - I

Course Outcomes:	
CO1	To understand the notion of group action and able to apply this to get some interesting results of Group actions like Class Equation etc
CO2	Able to learn Lagrange's Theorem , structure theory of groups, solvability and nilpotency of groups
CO3	To understand the Symmetric groups , Alternating Groups and their simplicity
CO4	To know how to apply Sylow Theory to determine structure of groups of finite order
CO5	To understand the basic properties of Rings and Ideals

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5 1 0
Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION-A

Review of groups, Normal and subnormal series, Solvable groups, Nilpotent groups, Composition Series, Jordan-Holder theorem for groups. Group action, Stabilizer, orbit, Class equation and its applications, permutation groups, cyclic decomposition, conjugacy classes in permutation groups. Alternating group A_n, Simplicity of A_n.

SECTION-B

Structure theory of groups, Fundamental theorem of finitely generated abelian groups, Invariants of a finite abelian group,Groups of Automorphisms of cyclic groups, Sylow's theorems, Groups of order p^2, pq. Review of rings and homomorphism of rings, Ideals, Algebra of Ideals, Maximal and prime ideals, Ideal in Quotient rings, Field of Quotients of integral Domain, Matrix Rings and their ideals; Rings of Endomorphisms of Abelian Groups.

Books Recommended

1. Bhattacharya, Jain & Nagpaul : Basic Abstract Algebra, Second Edition (Ch. 6, 7, 8, 10)
2. Surjeet Singh, Qazi Zameeruddin : Modern Algebra
3. I.N. Herstein : Topics in Algebra, Second Edition

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MATM1102T: MATHEMATICAL ANALYSIS

Course Outcomes:	
CO1	Solve problems based on functional of several variables including Inverse function theorem, Implicit function theorem
CO2	Understand Measure spaces and Lebesgue measure
CO3	Identify measurable function, Riemann and lebesgue integrals.
CO4	Understand differentiation, functions of bounded variation, differentiation of an integral, absolute continuity, convex functions and Jensen's inequality.
CO5	Describe the applications in probability theory, real analysis, and many other fields in mathematics as functional analysis, approximation theory and PDE.

L	T	P	University Exam: 70
5	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

Section-A

Functional of several variables: Linear transformations, Derivatives in an open subset of $\mathbf{R}^n$, Chain Rule, Partial derivatives, Interchange of the order of differentiation, Derivatives of higher orders, Taylor's theorem, Inverse function theorem, Implicit function theorem. Algebras, σ- algebra, their properties, General measurable spaces, measure spaces, properties of measure, Complete measure, Lebesgue outer measure and its properties, measurable sets and Lebesgue measure, A non measurable set.

Section-B

Measurable function w.r.t. general measure. Borel and Lebesgue measurability. Integration of non-negative measurable functions, Fatou's lemma, Monotone convergence theorem, Lebesgue convergence theorem, The general integral, Integration of series, Riemann and Lebesgue integrals. Differentiation; Vitalis Lemma, The Dini derivatives, Functions of bounded variation, Differentiation of an Integral, Absolute Continuity, Convex Functions and Jensen's inequality.

Book Recommended

1. H.L. Royden: Real analysis, Macmillan Pub. co. Inc. 4th Edition, New York, 1993. Chapters 3, 4, 5 and Sections 1 to 4 of Chapter 11.
2. Walter Rudin: Principles of Mathematical Analysis, 3rd edition, McGrawHill, Kogakusha, 1976, International student edition. Chapter 9 (Excluding Sections 9.30 to 9.43)
3. T. Apostol, Mathematical analysis, Addison-Wesley, Reading, MA, 1957.

Navpreet Singh

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MATM1103T: TOPOLOGY-I

Course Outcomes:	
CO1	Can differentiate between finite, countable, uncountable sets and understand the concept of open-sets, closed set, interior and exterior points.
CO2	Can understand the topological properties like compactness, connectedness and the countability axioms and find their numerous uses in the course.
CO3	The concepts of basis and sub-basis of a space, of interior and closure set the stage for the most general study of continuity.
CO4	Enables the student to understand the special characters of the metric spaces as an important special case of a topological space.
CO5	Enables the student to use these concepts in other areas of their studies whenever needed and establishing the importance of rigorous proof in mathematics.

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Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION A

Cardinals: Equipotent sets, Countable and Uncountable sets, Cardinal Numbers and their Arithmetic, Bernstein's Theorem and the Continumm Hypothesis.

Topological Spaces: Definition and examples, Euclidean spaces as topological spaces, Basis for a given topology, Topologizing of Sets; Sub-basis, Equivalent Basis.

Elementary Concepts: Closure, Interior, Frontier and Dense Sets, Topologizing with pre-assigned elementary operations. Relativization, Subspaces.

Maps and Product Spaces: Continuous Maps, Restriction of Domain and Range, Characterization of Continuity, Continuity at a point, Piecewise definition of Maps and Neighbourhood finite families. Open Maps and Closed Maps, Homeomorphisms and Embeddings.

SECTION B

Cartesian Product Topology, Elementary Concepts in Product Spaces, Continuity of Maps in Product Spaces and Slices in Cartesian Products.

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Connectedness: Connectedness and its characterizations, Continuous image of connected sets, Connectedness of Product Spaces, Applications to Euclidean spaces. Components, Local Connectedness and Components, Product of Locally Connected Spaces. Path Connectedness.

Compactness and Countability: Compactness and Countable Compactness, Local Compactness, One-point Compactification, T_0, T_1, and T_2 spaces, T_2 spaces and Sequences and Hausdorfness of One-Point Compactification.

Axioms of Countablity and Separability, Equivalence of Second axiom, Separable and Lindelof in Metric Spaces. Equivalence of Compact and Countably Compact Sets in Metric Spaces.

Books Recommended

1. W.J. Pervin Foundations of General Topology, New York, Academic Press, Ch. 2 (Sections 2.1, 2.2), Section 4.2, and Ch 5 (Sec 5.1 to 5.3).
2. James Dugundji : TOPOLOGY. Allyn and Bacon. Relevant Portions from Ch.III (excluding Sec 6 and Sec 10) , Ch IV; (Sections 1-3) and ChV

References:

1. James Munkres: Topology,2nd Edition Pearson.
2. Steen and Seebach : Counterexamples in Topology, Dover Books.
3. Stephen Willard: General Topology Addison Wesley.
4. J. Kelley: Topology. Graduate Texts in Mathematics 27. Springer.

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MATM1104T: Differential Geometry

Course Outcomes:	
CO1	To calculate the curvature and torsion of curves and surfaces in the three-dimensional space
CO2	To study the geometry of curves and surfaces in three-dimensional space using calculus techniques
CO3	Use of the first and the second fundamental forms for computing the length of the curves on a surface and to determine the deviation of the surface from its tangent plane
CO4	To have an idea about the surfaces of the constant mean and Gaussian curvature which have interesting physical interpretations.
CO5	To have a thorough knowledge about the effect of the Gauss's remarkable theorem on the bending of the surface without stretching.
CO6	To apply the theory of geodesics to study geodesic curvature, geodesic equations and the surfaces of revolution

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Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two question from each sections A and B and compulsory questions of section C.

Section A

Curves in the planes and in space: arc length, unit-speed curves, reparametrization, regular curves, closed curves. Curvature: plane curves, space curves, torsion, Serret-Frenet formulae. Surfaces in three dimensions: smooth surfaces, regular and allowable surface patches, transition maps, smooth maps , local diffeomorphism, tangent space, derivatives of smooth maps, normals and orientability, The first fundamental form: Lengths of curves on surfaces, Isometries of surfaces in relation to symmetric bilinear forms, equiareal maps. Curvature of surfaces: The second fundamental form, the Gauss and Weingarten maps, Normal and geodesic curvatures , Gauss Equations. The Gaussian and mean curvatures , principal curvatures of a surface, Euler's theorem, Lines of curvature, Rodrigue's formula.

Section B

Flat surfaces, surfaces of constant mean curvature, parallel surfaces, Gaussian curvature of compact surfaces. Geodesics: Definition and basic properties, geodesic equations, geodesics of surfaces of revolution, geodesics as shortest paths, geodesic coordinates. Gauss' Theorema Egregium: The Gauss and Codazzi-Mainardi equations, Gauss equations in terms of Gaussian curvature of the

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surface patch, Gaussian curvature in terms of the coefficients of the first fundamental form. Gauss' remarkable theorem and applications. Minimal surfaces: Plateau's problem, Gauss map of a minimal surface.

Books Recommended

1. Andrew Pressley, Elementary Differential Geometry, Springer, Fourth Indian Reprint 2009.
2. T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications, 2012.
3. B. O'Neill, *Elementary Differential Geometry*, 2nd Ed., Academic Press, 2006.
4. C.E. Weatherburn, *Differential Geometry of Three Dimensions*, Cambridge University Press 2003.
5. D.J. Struik, *Lectures on Classical Differential Geometry*, Dover Publications, 1988.
6. S. Lang, *Fundamentals of Differential Geometry*, Springer, 1999.
7. B. Spain, *Tensor Calculus: A Concise Course*, Dover Publications, 200

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MATM1105T: Introduction to Computer and Programming using C

Course Outcomes:	
CO1	Have basic knowledge of computer hardware and software
CO2	Write, compile and debug programs in C language
CO3	Use different data types, operators and I/O functions in computer program
CO4	Design programs involving decision control statements, loop control statements and case control statements
CO5	Understand the implementation of arrays, pointers and functions
CO6	Use the file operations, character I/O, strings and pre-processor directives

L T P
5 1 0
Time Allowed: 3 hours

University Exam: 40
Internal Assessment: 10
Total: 50

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 6 marks each and section C will be of 16 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION -A

Characterization of Computers, types of Computers, the Computer generations. Basic Anatomy of Computers: memory unit, input-output unit, arithmetic logic unit, control unit, central processing unit, RAM, ROM, PROM, EPROM. Input-Output Devices

Computer Software: Introduction, types of software: application and systems software. Networking: Basics, types of networks (LAN, WAN, MAN), topologies, communication media, Operating System, Definition, functions and types of operating system.

Computer Languages: Machine Language, assembly language, high level language, 4GL, assembler, compiler and interpreter

Problem Identification, Analysis, Flowcharts, Decision tables, Pseudo codes and algorithms, Program coding, Program Testing and execution,

C Programming: character set, Identifiers and keywords, Data types, Declarations, Statement and symbolic constants, Input-output statements, Preprocessor commands,

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Operators and Expressions: Arithmetic, relational, logical, unary operators, others operators, Bitwise operators: AND, OR, complement precedence and Associating bitwise shift operators, Input-Output: standard, console and string function

SECTION-B

Control statements: Branching, looping using for, while and do-while Statements, Nested control structures, switch, break, continue statements.

Functions: Declaration, Definition, Call, passing arguments, call by value, call by reference, Recursion, Use of library functions; Storage classes: automatic, external and static variables.

Arrays: Defining and processing arrays, Passing array to a function, Using multidimensional arrays, Solving matrices problem using arrays.

Strings: Declaration, Operations on strings.

Pointers: Pointer data type, pointers and arrays, pointers and functions.

Structures: Using structures, arrays of structures and union

Books Recommended

1. Norton Peter, Introduction to Computers, Tata McGraw Hill (2005).
2. Computers Today: Suresh K. Basandra, Galgotia, 1998.
3. Kerninghan B.W. and Ritchie D.M., The C programming language, PHI (1989)
4. Kanetkar Yashawant, Let us C, BPB (2007).
5. Rajaraman V., Fundamentals of Computers, PHI (2004).
6. Shelly G.B., Cashman T.J., Vermaat M.E., Introduction to computers, Cengage India Pvt Ltd (2008).

MATM1105L: SOFTWARE LABORATORY-I (C-Programming)

L	T	P	University Exam: 30
0	0	4	Internal Assessment: 20
Time Allowed: 3 hours			Total:50

This laboratory course will mainly comprise of exercises on what is learnt under the paper," Computer Programming using C".

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MATM1106T: MATHEMATICAL STATISTICS

Course Outcomes:	
CO1	Knowledge of the theory of statistics through mathematical techniques
CO2	To understand the axiomatic approach to probability with reference to the conceptual details of the set theory
CO3	Demonstration of the uses of specific parametric families of univariate density functions in day to day life
CO4	To obtain various generating functions for different discrete and continuous distributions and derive their properties
CO5	To understand the concept of sampling and some important sampling distributions to make inferences about the population
CO6	To apply the knowledge of two important aspects of statistical inference- estimation and test of hypothesis in various feasible statistical and mathematical spheres

L T P
5 1 0
Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION-A

Algebra of sets, fields, limits of sequences of subsets, sigma-fields generated by a class of subsets. Probability measure on a sigma-field, probability space. Axiomatic approach to probability.

Real random variables, distribution functions, discrete and continuous random variables, decomposition of a distribution function, Independence of events. Expectation of a real random variable. Linear properties of expectations, Characteristic functions, their simple properties

Discrete probability distributions: Binomial distribution, Poisson distribution, negative binomial distribution, geometric distribution, Hypergeometric distribution, power series distribution.

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Continuous probability distributions: Normal distribution, rectangular distribution, gamma distribution, beta distribution of first and second kind, exponential distribution. distribution of order statistics and range.

SECTION- B

Theory of Estimation: Population, sample, parameter and statistic, sampling distribution of a statistic, standard error. Interval estimation, Methods of estimation, properties of estimators, confidence intervals.

Exact Sampling Distributions: Chi-square distribution, Student's t-distribution, Snedecor's F-distribution, Fisher's z-distribution .

Hypothesis Testing: Tests of significance for small samples, Null and Alternative hypothesis , Critical region and level of significance. Tests of hypotheses: most powerful and uniformly most powerful tests, likelihood ratio tests. Tests of significance based on t, Z and F distributions, Chi square test of goodness of fit. Large Sample tests, Sampling of attributes, Tests of significance for single proportion and for difference of proportions, Sampling of variables, tests of significance for single mean and for difference of means and for difference of standard deviations.

Books Recommended :

1. Goon, A. M., Gupta, M. K., & Dasgupta, B. (2003). *An outline of statistical theory(Vol 1 & 2)*. World Press Pvt Limited.
2. Lehmann, E. L., & Casella, G. (1998). *Theory of point estimation* (Vol. 31). Springer Science & Business Media.
3. Lehmann, E. L., & Romano, J. P. (2006). *Testing statistical hypotheses*. Springer Science & Business Media.
4. Rohatgi, V. K., & Saleh, A. M. E. (2011). *An introduction to probability and statistics*. John Wiley & Sons.

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MATM1107T: LINEAR PROGRAMMING

Course Outcomes: After studying this course the students will be able to	
CO1	Model a problem as a linear programming problem and to apply the appropriate method in order to find an optimal solution
CO2	Formulate a given simplified description of a suitable real-world problem as a linear programming model in general, standard and canonical forms
CO3	Understand dual nature of linear programming problem and their solution
CO4	Analyze the effect of parametric changes on Optimal solution.
CO5	Understand the solutions of job sequencing problems of various type like n jobs on m machines.
CO6	Understand replacement policy for machinery which degenerates with time with/without considering any change in value of money

L	T	P
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Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

Section-A

Linear programming problems (LPPs): Examples, Mathematical formulation, Graphical solution, Solution by Simplex method, Artificial variables, Big-M method and two phase simplex method.

Duality in linear programming: Concept, Mathematical formulation, Fundamental properties of duality, duality and simplex method and Dual simplex method.

Sensitivity Analysis: Discrete changes in the cost vector, requirement vector and co-efficient matrix, addition of a new variable, deletion of a variable, addition of new constraint, deletion of a constraint.

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Section -B

Sequencing Problems; General Assumptions and basic terms used in sequencing, Processing n jobs through 2 machines, processing n jobs through 3 machines, Processing n jobs through m machines, Processing 2 jobs through m machines

Replacement decisions; O.R methodology of solving replacement problems, Replacement of items that deteriorates with time without change in the money value, Replacement of items that deteriorates with time with change in the money value.

RECOMMENDED BOOKS

1. Kanti Swarup, P.K. Gupta and Manmohan: 'Operations Research', Sultan Chand and Sons, New Delhi.
2. Chander Mohan and Kusum Deep: Optimization Techniques, New Age International, 2009.
3. H.S. Kasana, and K.D. Kumar : Introductory Operations Research, SIE 2003
4. Hamdy A Taha, Operations Research – An Introduction, Pearson.

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MATM1201T: ALGEBRA-II (RINGS AND MODULES)

Course Outcomes:	
CO1	To understand the connection between PID, ED and UFD
CO2	To understand the division algorithm in Polynomial Rings
CO3	Able to understand the concepts of modules, submodules and their properties
CO4	To understand the difference of Modules and Vector Spaces and can see modules as generalization of vector spaces
CO5	To know the concepts of Simple modules, Artinian Modules, Noetherian Modules and their simple characterizations

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Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two question from each sections A and B and compulsory question of section C.

SECTION-A

Unique Factorization Domains, Principal Ideal Domains, Euclidean Domains, Polynomial Rings over UFD, Rings of Fractions. (RR1: Ch. 11 and Section 1 of Chapter 12).

Modules: Definition and Examples, Submodules, Direct sum of submodules, Free modules, Difference between modules and vector spaces, Quotient modules, Homomorphism, Simple modules, Modules over PID. (RR2: Chapter 5)

SECTION - B

Modules with chain conditions: Artinian Modules, Noetherian Modules, Artinian Implies Noetherian in Rings, Composition series of a module, Length of a module, Hilbert Basis Theorem (RR2: Chapter 6).

Cohen Theorem, Radical Ideal, Nil Radical, Jacobson Radical, Radical of an Artinian ring. Nil Radical and Jacobson Radical of Polynomial Rings R[x], R commutative. (RR2: Chapter 6)

Books Recommended

1. Bhattacharya, Jain and Nagpaul: Basic Abstract Algebra, Second Edition.
2. Musili C., Introduction to Rings and Modules, Second Revised Edition.

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MATH1202T: TOPOLOGY II

Course Outcomes:	
CO1	Knowledge of convergence in mathematics through filters, regularity, complete regularity and normality of topological spaces.
CO2	Able to understand the modern language of Categories and Functors through the study of Homotopy
CO3	Introduce the idea of universal properties through the study of Stone Cech Compactification of Tichonov spaces.
CO4	The standard material of Identification spaces and their applications are established.
CO5	Enable the student to see the link between Algebra and Topology by proving the fundamental theorem of Algebra through Topological ideas.
CO6	Prepares the student for their future study of Algebraic Topology and the study of Natural Transformations in Mathematics.

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Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two question from each sections A and B and compulsory question of section C.

SECTION-A

Higher Separation Axioms : Regular, Completely Regular, Normal and Completely Normal Spaces. Metric Spaces as Completely Normal T_2 Spaces. Urysohns Lemma and The Tietze Extension Theorem.

Products : Products of first countable, Regular, T_2 and Completely Regular Spaces. Non invariance of normality under products. Embedding of Tichonov spaces into parallelotope and the Stone Cech Compactification.

Filters : Filter and filterbase, convergence and clustering, filter characterization of closure, continuity and filter convergence, ultrafilters, filter characterization of compactness and the Tychonoff Theorem.

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SECTION –B

Identification Topology: Identification Topology, Identification Map, Subspaces, General Theorem, Transgression, Transitivity, Spaces with Equivalance Relation, Quotient Spaces.

Categories and Functors: Categories: Definition and Examples, The Arrow Category, Congruence in a Category, Quotient Category, Functors, Duality, Contravariance and Duality, Homotopy as Congruence in Top, The Category hTop, homotopy equivalence, nullhomotopy.

Books Recommended

1. W.J. Pervin : Foundations of General Topology, (Sections 2.3 to 2.5), Section 5.5 to 5.6
2. Stephen Willard : GENERAL TOPOLOGY Ch 4 (excluding section 10), Ch 6 (Theorems 17.4 and 17.8 only)
3. James Dugundji : TOPOLOGY. Chapter VI,VII (1.3(3), 2.3(2), 3.3(3), 7.2 to 7.4 only and theorem 8.2 of Chapter XI)
4. Joseph J. Rotman: An Introduction to Algebraic Topology. Relevant Portions from Chapter 0 and Chapter 1.

References:

1. James Munkres: Topology,2nd Edition Pearson.
2. Steen and Seebach : Counterexamples in Topology, Dover Books.
3. Stephen Willard: General Topology Addison Wesley.
4. J. Kelley: Topology. Graduate Texts in Mathematics 27. Springer.

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MATH1203T: DIFFERENTIAL EQUATIONS-1

Course Outcomes:	
CO1	Know the concepts of existence, uniqueness and continuity of the solutions of first order ordinary differential equations.
CO2	Identify the properties of the zeros of solutions of linear nth order ordinary differential equations.
CO3	Analyze the dependence of solutions on initial conditions and parameters.
CO4	Demonstrate the knowledge of eigen values and eigen functions of sturmliouville systems.

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University Exam: 70
Internal Assessment: 30
Total: 100

Time Allowed: 3 hours

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION- A

Existence of solution of ODE of first order, initial value problem, Ascoli's Lemma, Gronwall's inequality, Cauchy Peano Existence Theorem, Uniqueness of Solutions. Method of successive approximations, Existence and Uniqueness Theorem.

System of differential equations, nth order differential equation, Existence and Uniqueness of solutions, dependence of solutions on initial conditions and parameters.

SECTION- B

Linear system of equations (homogeneous & non homogeneous). Superposition principle, Fundamental set of solutions, Fundamental Matrix, Wronskian, Abel Liouville formula, Reduction of order, Adjoint systems and self adjoint systems of second order, Floquet Theory.

Linear 2nd order equations, preliminaries, Sturm's separation theorem, Sturm's fundamental comparison theorem, Sturm Liouville boundary value problem, Characteristic values &

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Characteristic functions, Orthogonality of Characteristic functions, Expansion of a function in a series of orthonormal functions.

Books Recommended

1. E. Coddington & N. Levinson, Theory of Ordinary Differential Equations, Tata Mc-Graw Hill, India
2. S.L. Ross, Differential Equations, 3rd edition, John Wiley & sons (Asia).
3. D.A. Sanchez, Ordinary Differential Equations & Stability Theory, Freeman & company.
4. A.C. King, J. Billingham, S.R. Otto, Differential Equations, Linear, Nonlinear, Ordinary, Partial, Cambridge University Press.

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MATH1204T: COMPLEX ANALYSIS

Course Outcomes:	
CO1	Study the theory of complex variable with reference to theory real variables
CO2	Analyse the behaviour of derivative of a function of a complex variable
CO3	To deal effectively with the numerical concepts related to analytic functions and harmonic functions
CO4	Construction of various methods to deal with complex integration
CO5	To investigate the behaviour of a function at the singularities through various series expansions
CO6	To deal with the concept of analytic continuation by extending the domain of analyticity

L	T	P
5	1	0

Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two question from each sections A and B and compulsory question of section C.

SECTION-A

Function of complex variable, Analytic function, Cauchy-Riemann equations, Harmonic function and Harmonic conjugates, Branches of multivalued functions with reference to arg z, logz and z^c, Conformal Mapping. Complex Integration, Cauchy's theorem, Cauchy Goursat theorem Cauchy integral formula, Morera's theorem, Liouville's theorem, Fundamental theorem of Algebra, Maximum Modulus Principle. Schwarz lemma.

SECTION-B

Taylor's theorem. Laurent series in an annulus. Singularities, Meromorphic function. Cauchy's theorem on residues. Application to evaluation of definite integrals. Principle of analytic continuation, General definition of an analytic function. Analytic continuation by power series method, Natural boundary, Harmonic functions on a disc, Schwarz Reflection principle, Mittag-

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Leffler's theorem (only in case when the set of isolated singularities admits the point at infinity alone as an accumulation point).

Books Recommended

1. L.V.Ahlfors, Complex Analysis, 3rd edition.
2. E.T.Copson, An introduction to Theory of Functions of a Complex Variable
3 H.S. Kasana, Complex Variables, Prentice Hall of India
4. Herb Silverman, Complex Variables, Houghton Mifflin Company Boston

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MATM1205T: PROGRAMMING USING PYTHON

Course Outcomes:	
CO1	To learn and understand Python programming basics and paradigm
CO2	To learn and understand Python looping, control statements and string manipulations
CO3	To acquire Object Oriented Skills in Python.
CO4	To learn and know the concepts of file handling and exception handling in Python

L	T	P
5	1	0

Time Allowed: 3 hours

University Exam: 40
Internal Assessment: 10
Total: 50

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 6 marks each and section C will be of 16 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION-A

Introduction to Python: History of python, strength and weakness, different versions, installing python, python identifiers and reserved key words.

Python syntax: Variables and variables type, data types, data types conversion, operators (arithmetic, comparison, assignment, bitwise, logical, membership, identity), operators precedence, python decision making (if, else if, else, nested if), python loops (while, for, nested loops), break and continue statements.

Python Functions and Data Structures: Function Specifications, Global Variables, Modules, Passing parameters to Functions, scope of variables (global and local), Recursive functions, Lambda function in python, Python String and string operations, List, Tuple, Set, And Dictionary Manipulations

SECTION-B

Python Modules: Modules, standard modules (sys, math, time), import statement, from statement.

Python File handling: Opening a file, Understanding read functions: read(), readline() and readlines(), Understanding write functions: write() and writelines(), writing data to a file, closing files.

Python Exception handling: What is exception, Handling an exception, try…except…else, try-finally clause, Argument of an exception, Raising an exception, User-defined exceptions.

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Python Object Oriented Programming: OOPs Concept of class, object and instances, Constructor, class attributes and destructors, Method overloading in python, Operator overloading, Inheritance.

BOOKS RECOMMENDED:

1. Wesley J Chun: *Core Python Applications Programming*, Third Edition. Pearson Publication
2. P.Gries, Jennifer Campbell, Jason Montojo: *Practical Programming- An Introduction to Computer Science Using Python 3.6*, Shroff Publications and Distributors.
3. J. V.Guttag: *Introduction to Computation and Programming Using Python*, Revised and expanded Edition, MIT Press , 2013.
4. James Payne : *Beginning Python: Using Python 2.6 and Python 3.1,* Wrox Publication
5. Wesley J Chun: *Core Python Programming*, Prentice Hall
6. Ashok Namdev Kamthane, Amit Ashok Kamthane: *Programming and Problem Solving with Python,* Mcgraw Hill Education
7. R. Sedgewick, Kevin Wayne, Robert Dondero, *Introduction to Programming in Python: An Inter-disciplinary Approach*, Pearson India Education Services Pvt. Ltd., 2016.
8. T. A. Budd: *Exploring Python*, Mc-Graw Hill Education (India) Private Ltd., 2015.
9. P.Gries, Jennifer Campbell,Jason Montojo: *Practical Programming: An Introduction to Computer Science using Python 3*, Second edition, Pragmatic Programmers, LLC, 2013.
10. Campbell: *Practical Programming: An Introduction to Computer Science Using Python*, Shroff Publications and Distributors.

MATM1205L: SOFTWARE LABORATORY-II (PYTHON PROGRAMMING)

L	T	P
0	0	4

Time Allowed: 3 hours

University Exam: 30
Internal Assessment: 20
Total:50

This laboratory course will mainly comprise of exercises on what is learnt under the paper," PROGRAMMING USING PYTHON ".

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MATH1206T: FUNCTIONAL ANALYSIS

Course Outcomes:
Understand and apply fundamental theorems Hahn-Banach theorem in Normed linear spaces and its applications, uniform boundedness principle, open mapping theorem, closed graph theorem.
Understand Hilbert spaces including orthogonality, orthonormal sets, Bessel's inequality, Parseval's theorem.
Use and derive basic definitions and theorems of functional analysis
Differentiate between Banach Space and Hilbert Space
Apply contraction and approximation theory in differential equations and integral equations.

L	T	P
5	1	0

Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION-A

Normed Linear spaces, Banach spaces, Examples of Banach spaces and subspaces. Continuity of Linear maps, Equivalent norms. Normed spaces of bounded linear maps. Bounded Linear functional. Hahn-Banach theorem in Linear Spaces and its applications.

Hahn-Banach theorem in normed linear spaces and its applications.Uniform boundedness principle, Open mapping theorem, Projections on Banach spaces, Closed graph theorem.

SECTION-B

The conjugate of an operator. Dual spaces of lp and C [a,b], Reflexivity. Hilbert spaces, examples, Orthogonality, Orthonormal sets, Bessel's inequality, Parseval's theorem. The conjugate space of a Hilbert spaces. Adjoint operators, Self-adjoint operators, Normal and unitary operators. Projection operators. Spectrum of an operator, Spectral Theorem, Banach

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Fixed Point Theorem, Brower's Fixed Point Theorem. Schauder Fixed Point Theorem, Picards Theorem. Applications of Fixed point theorem in differential equations and integral equations.

Books Recommended

1. G.F.Simmons : Introduction to Toplogy and modern Analysis, Chapters IX, X , XII and appendix one.

Reference Books

1. George Bachman & Lawrence Narici: Functional Analysis.
2. E. Kreyszig, Introductory Functional Analysis with applications
3. Abul Hasan Siddiqi , Applied Functional Analysis. Marcel Dekker.

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MATH1207T: CLASSICAL MECHANICS

Course Outcomes:	
CO1	Determine the Lagrangian and Hamiltonian functions for a physical systems
CO2	Derive and solve the equations of motion from these functions
CO3	Determine the moments of inertia of a rigid body.
CO4	Identify symmetries and to derive the corresponding conservation laws
CO5	Perform calculations using relativistic kinematics and conservation laws

L	T	P
5	1	0

Time Allowed: 3 hours

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER – SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each sections A and B and compulsory question of section C.

SECTION-A

Basic Principles: Mechanics of a Particle and a System of Particles, Constraints , Generalized Coordinates, Holonomic and Non-Holonomic Constraints. D'Alemberts Priciple and Lagrange's Equations, Velocity Dependent Potentials and the Dissipation Function, Simple Applications of the Lagrangian formulation.

Variational Principles and Lagrange's Equations: Hamilton's Principle, Derivation of Lagrange's Equations from Hamilton's Principle, Extension of Hamilton's Principle to Non-Holonomic Systems.

Conservation Theorems and Symmetry Properties: Cyclic Coordinates, Canonical Momentum and its Conservation, The Generalized Force, and Angular Momentum Conservation Theorem.

The Two-Body Central Force Problem: Reduction to the Equivalent One-Body Problem, The Equation of Motion, The Equivalent One Dimensional Problem and the Classification of Orbits, The Virial Theorem, Conditions for Closed Orbits, Bertrand's Theorem.

SECTION - B

The Kepler Problem: Inverse Square Law of Force, The Motion in Time in the Kepler Problem, Kepler's Laws, Kepler's Equation, The Laplace-Runge-Lenz Vector.

Scattering in a Central Force Field: Cross Section of Scattering, Rutherford Scattering Cross Section, Total Scattering Cross Section, Transformation of the Scattering Problem to Laboratory Coordinates.

The Kinematics of Rigid Body Motion: The Independent Coordinates of Rigid Body, The Transformation Matrix, The Euler Angles, The Cayley-Klein Parameters and Related Quantities,

Mashrat Sinha
Chauhan

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Euler's Theorem on the Motion of Rigid Bodies, Finite Rotations, Infinitesimal Rotations, The Coriolis Force.

BOOKS RECOMMENDED

1. Herbert Goldstein: Classical Mechanics 3rd edition Addison-Wesley.

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Open Elective (For Post Graduate Students) (QUALIFYING PAPER)

Basic Calculus

L	T	P
3	0	0

Time Allowed: 3 hours
3 Credit Course

University Exam: 70
Internal Assessment: 30
Total: 100

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each from the respective sections of the syllabus. Section C will consist of one compulsory question having ten short questions covering the entire syllabus uniformly. Each question in sections A and B will be of 10 marks each and section C will be of 30 marks.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt five questions in all selecting two questions from each of the Section A and B and compulsory question of Section C.

Section-A

Functions, Limits and Continuity, Right and Left Hand Limits, Theorems on Limits (Without Proofs). Continuity, The Derivative, Rules for Differentiating Functions, Composite Functions, Chain Rule, Higher Derivatives. Implicit Differentiation. Increasing and Decreasing Funtions, Maximum and Minimum Values.

Section-B

Antiderivative, The Definite Integral. Area under a curve, properties of the definite integral. The Mean Value Theorem for Integrals, Average Value of a Function on a closed Interval, Fundamental Theorem of Calculus. Exponential Growth and Decay. Arc and Arc length.

References

1. **Frank Ayre, Jr and Elliot Mendelson**: ***Calculus*** Sixth Edition, Schaum's Outlines. McGraw Hill (Relevant Portions from Chapters 7 to 11, Chapter 13 to 14, Chapters 22 -24 and Chapters 28 to 29.

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