M.Sc. MATHEMATICS

Scheme and Syllabus

OUTCOME BASED EDUCATION SYSTEM (OBES)/
Learning Outcomes based Curriculum Framework (LOCF)
Choice Base Credit System (CBCS)
ACADEMIC SESSION

(w.e.f. 2021-2022)

DEPARTMENT OF MATHEMATICS

FACULTY OF SCIENCES

J C BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY, YMCA,
FARIDABAD HARYANA -121006

J C BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY, YMCA, FARIDABAD

VISION

J C BOSE University of Science and Technology, YMCA aspires to be a nationally and internationally acclaimed leader in technical and higher education in all spheres which transforms the life of students through integration of teaching, research and character building.

MISSION

- To contribute to the development of science and technology by synthesizing teaching, research and creative activities.
- To provide an enviable research environment and state-of-the art technological exposure to its scholars.
- To develop human potential to its fullest extent and make them emerge as world class leaders in their professions and enthuse them towards their social responsibilities

DEPARTMENT OF MATHEMATICS

VISION

To emerge as a department of science, which will provide strong foundations in the areas of Pure and Applied Mathematics in order to develop innovative minds for interdisciplinary research.

MISSION

- To develop strong communication skills among students.
- To develop strong moral values.
- To develop strong foundations in mathematics to have sound analytical and critical thinking ability for innovative solutions in practical problems.
- To continuously improve the basic infrastructure in pursuit of providing necessary environment for academic excellence.
- To develop a nurturing environment for lifelong learning.

ABOUT THE PROGRAM: M.Sc. MATHEMATICS

M.Sc. Mathematics/Master of Science Mathematics is a postgraduate program. Mathematics is considered as a tough subject, getting a post graduate degree in Mathematics is always considered as a challenging task. M.Sc. Mathematics deals with all the theorems, derivations and applications that come under the syllabus.

Minimum eligibility for the student to join M.Sc. Mathematics is to have a bachelor's degree with mathematics as the main subject. The candidates having degree of M.Sc. Mathematics have many job opportunities in various fields. M.Sc. Mathematics graduates can work in banks, colleges/universities, share markets, space agencies, research etc.. The students become more skilled and specialized in a particular subject after the master degree program

M.Sc. Mathematics is a two-year postgraduate program which is being divided into four semesters. This degree has been awarded to those who complete the program. In this degree, candidates get a deeper knowledge of advanced mathematics through a vast preference of subjects such as algebra, real analysis, operational research, complex analysis, mechanics, calculus of variations, ODEs and PDEs, dynamical systems, differential and integral equations, etc..

PROGRAM OUTCOMES OF PG PROGRAM OF FACULTY OF SCIENCES

PO1	**Knowledge**	Capable of demonstrating comprehensive disciplinary knowledge gained during course of study
PO2	**Research Aptitude**	Capability to ask relevant/appropriate questions for identifying, formulating and analyzing the research problems and to draw conclusion from the analysis
PO3	**Communication**	Ability to communicate effectively on general and scientific topics with the scientific community and with society at large
PO4	**Problem Solving**	Capability of applying knowledge to solve scientific and other problems
PO5	**Individual and Team Work**	Capable to learn and work effectively as an individual, and as a member or leader in diverse teams, in multidisciplinary settings.
PO6	**Investigation of Problems**	Ability of critical thinking, analytical reasoning and research-based knowledge including design of experiments, analysis and interpretation of data to provide conclusions
PO7	**Modern Tool usage**	Ability to use and learn techniques, skills and modern tools for scientific practices
PO8	**Science and Society**	Ability to apply reasoning to assess the different issues related to society and the consequent responsibilities relevant to the professional scientific practices
PO9	**Life-Long Learning**	Aptitude to apply knowledge and skills that are necessary for participating in learning activities throughout life
PO10	**Ethics**	Capability to identify and apply ethical issues related to one's work, avoid unethical behaviour such as fabrication of data, committing plagiarism and unbiased truthful actions in all aspects of work
PO11	**Project Management**	Ability to demonstrate knowledge and understanding of the scientific principles and apply these to manage projects

PROGRAM SPECIFIC OUTCOMES (PSOs)

The program specific outcomes (PSO's) are the statement of competencies/abilities that describes the knowledge and capabilities of the post-graduate will have by the end of program studies.

After successful completion of M. Sc. MATHEMATICS program, the students will be able to

PSO1	Work as a mathematical professional, or to qualify for training as scientific researcher. Students shall be proficient in fundamentals of Pure and Applied Mathematics.
PSO2	Utilize the mathematical problem-solving methods such as analysis, modeling, and programming and mathematical software applications in addressing the practical issues. Apply Mathematical Techniques in various computer software such as C, C++ and MATLAB.
PSO3	Pursue higher studies and to take up the career in various mathematical computer science based industries and in teaching field.

Student Grades

The academic performance of a student shall be graded on a TEN-PONT SCALE and the award of grades based upon obtained out of 100 shall be made as follows: -

*Percentage	Grade	Grade Points	Category
90--100	O	10	Outstanding
80	A+	9	Excellent
70	A	8	Very Good
60	B+	7	Good
50	B	6	Above Average
45	C	5	Average
40	P	4	Pass
	F	0	Fail
.....	Ab	0	Absent

Cumulative Grade Point Average (CGPA)

A Student is required to maintain a Cumulative Grade Point Average (GCPA) which is the weighted average of all the Letter Grade obtained by the student since his/her entry into the Institute up to and including the latest semester and computed as follows:

Where denotes credits assigned to 1th course and indicates the Grade point equivalent to the Letter Grade obtained by the students to the course. Provided that when a student re-appears in /repeats a course, the new Grade will replace the earlier one in the calculations of the CGPA.

Note:

i. At the end semester (i.e. after End Semester Examination).student will be supplied a DMC indicating the grades secured in each course, Semester Grade point Average (SGPA) and up to date CGPA.

ii. Multiplication factor for converting the CGPA in Percentage will be Provided on the respective Detailed Marks Certificate (DMC)

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DEPARTMENT OF MATHEMATICS

SCHEME M.SC. MATHEMATICS

SEMESTER I

S. No.	Subject Code	Title	L	T	P	Internal Assessment	End-semester Examination	Total	Credits	Category Code*
1	MATH21-701	Real Analysis	4	0	0	25	75	100	4	DCC
2	MATH21-702	Abstract Algebra	4	0	0	25	75	100	4	DCC
3	MATH21-703	Ordinary Differential Equations	4	0	0	25	75	100	4	DCC
4	MATH21-704	Complex Analysis	4	0	0	25	75	100	4	DCC
5	MATH21-705	Programming in C (Theory)	4	0	0	25	75	100	4	DCC
6	MATH21-706	Programming in C Lab	0	0	4	30	70	100	2	DCC
	XXX	MOOC**								MOOC
	VAC01	Human Values and Professional Ethics								VAC
	Total		**20**	**0**	**4**	**155**	**445**	**600**	**22**	

* DCC – Discipline Core Course; VAC - Value Added Course; MOOC – Massive Open Online Course; L – Lecture; T - Tutorial; P - Practical

**The students have to pass at least one mandatory MOOC course with 4-6 credits (12-16 weeks) from the list given on the Swayam portal or the list given by the Department/ University from 1st semester to 3rd semester as notified by the University. (Instructions to students overleaf)
***The students have to pass at least one mandatory VAC course offered by the University from 1st semester to 3rd semester as notified by the University.

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DEPARTMENT OF MATHEMATICS

SCHEME M.SC. MATHEMATICS

SEMESTER II

S. No.	Subject Code	Title	L	T	P	Internal Assessment	End-semester Examination	Total	Credits	Category Code*
1	MATH21-751	Mathematical Statistics	4	0	0	25	75	100	4	DCC
2	MATH21-752	Linear Algebra	4	0	0	25	75	100	4	DCC
3	MATH21-753	Mathematical Methods	4	0	0	25	75	100	4	DCC
4	MATH21-754	Numerical Methods	4	0	0	25	75	100	4	DCC
5	MATH21-755	Programming in C++(theory)	4	0	0	25	75	100	4	DCC
6	MATH21-756	Programming in C++ lab	0	0	4	30	70	100	2	DCC
	XXX	Audit Course*	2	0	0	25	75	100	0	AUD

	Total		**20**	**0**	**4**	**155**	**445**	**600**	**22**	

- DCC – Discipline Core Course; AUD-Audit Course; L – Lecture; P - Practical
- *provided by the Department/ University along with subject code and syllabus.
- *URL for various department OEC and Audit Courses https://jcboseust.ac.in/postgraduate-programmes

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DEPARTMENT OF MATHEMATICS

SCHEME M.SC. MATHEMATICS

SEMESTER III

S. No.	Subject Code	Title	L	T	P	Internal Assessment	End-semester Examination	Total	Credits	Category Code*
1	MATH21-801	Topology	4	0	0	25	75	100	4	DCC
2	MATH21-802	Mechanics and Calculus of Variations	4	0	0	25	75	100	4	DCC
3	MATH21-803	Partial Differential Equations	4	0	0	25	75	100	4	DCC
4	MATH21-804	Operations Research	4	0	0	25	75	100	4	DCC
5	MATH21-805	*Discipline Elective Course	4	0	0	25	75	100	4	DEC
6	MATH21-806	MATLAB	0	0	4	30	70	100	2	DCC

	XXX	**Open Elective Course	3	0	0	25	75	100	3	OEC
	Total		**20**	**0**	**4**	**155**	**445**	**600**	**22**	
*Discipline Elective Course: Select any one course from the following:										
5A	MATH21-805A	Mechanics of Solids	4	0	0	25	75	100	4	DEC
5B	MATH21-805B	Analytical Number Theory	4	0	0	25	75	100	4	DEC
5C	MATH21-805C	Advanced Complex Analysis	4	0	0	25	75	100	4	DEC

- * Students will have to choose one out three specializations offered by the department. The choice will be granted on merit basis **OEC – Open Elective Course; L – Lecture; T-Tutorial, P – Practical, **VAC-Value Added Course** URL for various department OEC and Audit Courses https://jcboseust.ac.in/postgraduate-programmes

- *OEC: A students required to choose open elective course offered by the other departments in the faculty of Sciences.

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DEPARTMENT OF MATHEMATICS

SCHEME M.SC. MATHEMATICS

SEMESTER IV

S. No.	Subject Code	Title	L	T	P	Internal Assessment	End-semester Examination	Total	Credits	Category Code*
1	MATH21-851	Functional Analysis	4	0	0	25	75	100	4	DCC

2	MATH21-852	Differential Geometry	4	0	0	25	75	100	4	DCC
3	MATH21-853	Fluid Dynamics	4	0	0	25	75	100	4	DCC
4	MATH21-854	Integral Equations	4	0	0	25	75	100	4	DCC
5	MATH21-855	*Discipline Elective Course	4	0	0	25	75	100	4	DEC
6	MATH21-856	# Project Work	0	0	8	30	70	100	4	DCC
		Total	**20**	**0**	**8**	**155**	**445**	**600**	**24**	
*Discipline Elective Course: Select any one course from the following:										
5A	MATH21-855A	Advanced Operation Research	4	0	0	25	75	100	4	DEC
5B	MATH21-855B	Advanced Discrete Mathematics	4	0	0	25	75	100	4	DEC
5C	MATH21-855C	Mathematical Modeling	4	0	0	25	75	100	4	DEC

- DCC – Discipline Core Course; DEC – Discipline Elective Course; L – Lecture; P - Practical
- * Students will continue with the same specialization as was chosen in Semester III.
- # Students will have to complete a dissertation in the respective specialization under the guidance of the supervisor. Formatting and description for dissertation writing will be provided.

Instructions to the students regarding MOOC

1. Two types of courses will be circulated: branch-specific and general courses from the website https://swayam.gov.in or https://nptel.ac.in/ in the month of June and November every year for the forthcoming semester.
2. The department coordinators will be the course coordinators of their respective departments.
3. Every student has to pass a selected MOOC course within the duration as specified below:

Programme	**Duration**
B. Tech.	Sem. I to Sem. VII
M.Sc./M.Tech. /M.A./MBA	Sem. I to Sem. III
B.Sc./MCA	Sem. I to Sem. V

The passing of a MOOC course is mandatory for the fulfillment of the award of the degree of concerned programme.

4. A student has to register for the course for which he is interested and eligible which is approved by the department with the help of the course coordinator of the concerned department.
5. A student may register in the MOOC course of any programme. However, a UG student will register only in UG MOOC courses and a PG student will register in only PG MOOC courses.
6. The students must read all the instructions for the selected course on the website, get updated with all key dates of the concerned course, and must inform his/her progress to their course coordinator.
7. The student has to pass the exam (online or pen-paper mode as the case may be) with at least 40% marks.
8. The students should note that there will be a weightage of Assessment/quiz etc. and final examination appropriately as mentioned in the instructions for a particular course.
9. A student must claim the credits earned in the MOOC course in his/her marksheet in the examination branch by forwarding his/her application through the course coordinator and chairperson.

Guidelines for Dissertation:

The purpose of the dissertation in M.Sc. 4th semester is to introduce research methodology to the students. It may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem related to subject, participation in some ongoing research activity, analysis of data, etc. The work can be carried out in any thrust areas of subject (Experimental or Theoretical) under the guidance of allotted supervisor of the department. The students must submit their dissertation in the department as per the date announced for the submission**.**

Internal assessment of the dissertation work will be carried out by respective supervisor through power point presentation given by candidates during the semester. External assessment of the dissertation work will be carried out by an external examiner (nominated by the Chairperson of the Department) through power-point presentation given by candidates. This load (equivalent to 2 hours per week) will be counted towards the normal teaching load of the teacher.

1. Dissertation will contain a cover page, certificate signed by student and supervisor, table of contents, introduction, Objective, Literature review, methodology, results and discussions conclusion, and references.

- The paper size to be used should be A-4 size.
- The font size should be 12 with Times New Roman.
- The text of the dissertation may be typed in 1.5 (one and a half) space.
- The print out of the dissertation shall be done on both sides of the paper (instead of single side printing)
- The total no. of written pages should be between 40 to 60 for dissertation.

2. The candidate shall be required to submit two soft bound copies of dissertation along with a CD in the department as per the date announced.

3. Dissertation will be evaluated internally by the supervisor allotted to the student during the semester.

4. The candidate will defend her/his dissertation/project work through presentation before the External examiner at the end of semester and will be awarded marks.

5. In case, a student is not able to score passing marks in the dissertation exam, he/she will have to resubmit her/his dissertation after making all corrections/improvements & this dissertation shall be evaluated as above. The candidate is required to submit the corrected copy of the dissertation in hard bound within two weeks after the viva -voce.

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DEPARTMENT OF MATHEMATICS

The department of MATHEMATICS offers the following Audit Courses and Open Elective Courses for the students of other departments in the Faculty of Sciences:

Course	Subject	Subject Code
Audit Course	1. Elementary Number theory	AC21-201B
Open Elective Course	1. Basics of Statistics	OMATH21-203A
	2. Graph theory	OMATH21-204A

- The students have to choose one Audit course (0 credit) from the list provided by the department/University. Only passing of the Audit course will be mandatory.
- The students have to choose one Open Elective Course (03 credits) related to other branch of Science/Engineering/other discipline required for enhancing professional performance as provided by the department/university.

M.Sc. MATHEMATICS SEMESTER I
CODE: MATH21-701
SUBJECT NAME: REAL ANALYSIS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Verify whether a given subset of P or a real valued function is measurable.
CO2: Understand the requirement and the concept of the Lebesgue integral (a generalization of the Reimann integration) along its properties
CO3 Demonstrate understanding of the statement and proofs of the fundamental integral convergence theorems and their applications.
CO4: Know about the concepts of functions of bounded variations and the absolute continuity of functions with their relations.
CO5: Learn and apply Holder and Minkowski inequalities in L^P -spaces and understand completeness of L^P -spaces and convergence in measures.

UNIT-I
Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue measurability, Non-measurable sets.

UNIT-II
Integration of non-negative functions, General integral, Fatou's lemma, Integration of series, Riemann and Lebesgue integrals.

UNIT-III
Functions of bounded variation, Lebesgue differentiation theorem, Differentiation and integration, Absolute continuity of functions, Measures and outer measures, Measure spaces, Integration with respect to a measure.

UNIT-IV

The -spaces, Holder and Minkowski inequalities, Completeness of -spaces, Convergence in measure, Almost uniform convergence, Egorov's theorem.

TEXT BOOKS

1. Barra G. de, *Measure Theory and Integration*, New Age International (P) Ltd., New Delhi, 2014.
2. Hewitt E. and Stromberg K., *Real and Abstract Analysis: A Modern Treatment of the Theory of Functions of a Real Variable*, Springer, Berlin, 1975.

REFERENCE BOOK

1. Capinski M. and Kopp E., *Measure, Integral and Probability*, Springer, 2005.
2. Royden H.L. and Fitzpatrick P.M., *Real Analysis*, 4th edition, Pearson, 2015.

M.Sc. MATHEMATICS SEMESTER I
CODE: MATH21-702
SUBJECT NAME: ABSTRACT ALGEBRA
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: Analyze and illustrate examples of composition series, normal series, subnormal series.

CO2: Learn properties and analysis of solvable & nilpotent groups and rings, Ideals, Prime and maximal ideals.

CO3: Apply Sylow's theorems to describe the structure of some finite groups and use the concepts of Eisenstein's irreduciblity criterion.

CO4: Use various canonical types of groups and Principal ideal domains, Unique factorization Domain, polynomial rings and Construction of finite fields.

UNIT I

Conjugacy, Class equations, p-groups, Sylow p-subgroups, Sylow theorems, Applications of Sylow theorems, Description of groups of order and , Survey of groups upto order 15.

UNIT II

Normal and subnormal series, Solvable series, Derived series, Solvable groups, Solvable groups, Solvability of -the symmetric group of degree $n \geq 2$, Central series, Nilpotent groups and their properties, Jordon Holder's Theorem.

UNIT III

Rings, Ideals, Prime and maximal ideals, Homomorphism, Quotient- rings, Integral domains, Field, Prime fields, Field of quotients of an Integral domain, Euclidean domains, Principal ideal domains, Unique factorization Domain.

UNIT IV

Gauss lemma, Eisenstein's irreducibility criterion, Primitive polynomials, Cyclotomic polynomials, Unique factorization in R[x] where R is a Unique factorization Domain, Finite fields, Construction of finite fields.

TEXT BOOKS

1. Gallian J. A., *Contemporary Abstract Algebra*.
2. David S. Dummit and Richard M. Foote, *Abstract Algebra*, Wiley.

REFERENCE BOOK

1. Herstein I.N., *Topics in Algebra*, New Age International (P) Limited, New Delhi, 2005.
2. Bhattacharya P. B., Nagpaul S.K., *Basic Abstract Algebra*, 2nd edition, Cambridge University Press, Indian Edition, 1997.

M.Sc. MATHEMATICS SEMESTER I

CODE: MATH21-703

SUBJECT NAME: ORDINARY DIFFERENTIAL EQUATIONS

NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: solve initial value problems, use knowledge about some basic existence uniqueness theorems related to the topic.

CO2: use power series and Frobenius method for solving differential equations, use Sturm theory for solving problems.

CO3: learn basic theory of linear systems, solve Linear system of differential equations.

CO4: use the basic terms and Liapunov method for non- linear differential equations.

UNIT I

Initial-value problem and the equivalent integral equation, e-approximate solution, Cauchy-Euler construction of an e-approximate solution, Equi-continuous family of functions, Ascoli-Arzela theorem, Cauchy-Peano existence theorem. Existence and uniqueness of solutions, Lipschitz condition, Picard-Lindelof theorem for local existence and uniqueness of solutions, solution of initial-value problems by Picard method.

UNIT II

Power Series Solutions, Review of power series, Series solutions of first order equations, Second order linear equations, Ordinary points, Regular singular points, Indicial equations, The point at infinity, Frobenius method.

Sturm Liouville Theory, Sturm separation theorem. Normal form, Sturm's comparison theorem, Sturm Liouville problems, Characteristic values and Characteristic functions in Sturm Liouville problems.

UNIT – III

System of Linear Differential Equations, Basic theory of linear systems in normal form, two equations in two unknown functions, homogeneous linear systems with constant coefficients, two equations in two unknown functions.

UNIT-IV

Non-linear differential equations, Autonomous systems, Phase plane, Critical points, Concepts of stability, Critical points and paths of linear system, Liapunov's direct method, Liapunov functions.

TEXT BOOKS

1. Ross S. L., *Differential Equations*, John Wiley and Sons Inc., NY, 1984.
2. Raisinghania M. D., *Ordinary Differential Equations*, S. Chand.

REFERENCE BOOKS

1. Coddington E. A. and Levinson N., *Theory of Ordinary Differential Equations*, McGraw Hill, NY, 1955.
2. Birkhoff G. and Rota G. C., *Ordinary Differential Equations*, John Wiley and Sons Inc..NY, 1978.
3. Boyce W. E. and Diprima R. C., *Elementary Differential Equations and Boundary Value Problems*, John Wiley and sons Inc., NY, 1986.

M.Sc. MATHEMATICS SEMESTER I
CODE: MATH21-704
SUBJECT NAME: COMPLEX ANALYSIS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: Integrate knowledge and ideas of analytic functions and Cauchy-Riemann equations in Cartesian and polar coordinates.

CO2: Understand Cauchy's theorems and integral formulas on open subsets of the plane.

CO3: Understand the integration of meromorphic functions with zeros and poles leading to the argument principle and Rouche's theorem.

CO4: Develop the understanding of conformal mappings.

UNIT -I

Analytic functions and their properties, Cauchy-Riemann equations in cartesian and polar coordinates, Power series, Radius of convergence, Differentiability of sum function of a power series, Branches of many valued functions with special reference to argz , logz and z^a.

UNIT -II

Path in a region, Contour, Complex integration, Cauchy's theorem, Cauchy's integral formula, Extension of Cauchy's integral formula for multiple connected domains, Poisson integral formula, Higher order derivatives, Complex integral as a function of its upper limit, Morera's theorem, Cauchy's inequality, Liouville's theorem.

UNIT – III

Zeros of an analytic function, Taylor series, Laurent series, Isolated singularities, Cassorati-Weierstrass theorem, Limit point of zeros and poles, Maximum modulus principle, Schwarz's lemma, Meromorphic functions, Argument principle, Rouche's theorem, Fundamental theorem of algebra, Inverse function theorem.

UNIT – IV

Calculus of residues, Cauchy's residue theorem, Application of residue theorem in evaluation of improper real integrals and evaluation of sum, Definitions and examples of conformal mappings, Bilinear transformations, their properties and classifications, Orientation principle.

TEXT BOOKS

1. Conway J. B., *Functions of one Complex variable*, 2nd edition, Narosa Pub., New Delhi, 1996.
2. Goyal and Gupta, Functions of a *Complex Variable*, Pragati Edition, 2016.

REFERENCE BOOKS

1. Churchill R. V. and Brown J. W., *Complex Variables and Applications*, McGraw-Hill Publishing Company, 2009.
2. Priestly H. A., *Introduction to Complex Analysis*, Clarendon Press, Oxford, 1990
3. Ahlfors L. V., *Complex Analysis*, 3rd edition, Mc Graw Hill Co., Indian Edition, 2017.
4. Rudin W, *Real and Complex Analysis*, 3rd edition, Mc Graw Hill, 1987

M.Sc. MATHEMATICS SEMESTER I
CODE: MATH21-705
SUBJECT NAME: PROGRAMMING IN C
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Develop simple applications in C using basic constructs.
CO2: Design and implement applications using arrays and strings.
CO3: Develop and implement applications in C using functions and pointers.
CO4: Design applications using sequential and random-access file processing.

UNIT I
Introduction to programming paradigms, Structure of C program, C programming: Data Types, Storage classes, Constants, Enumeration Constants, Keywords, Operators: Precedence and Associativity, Expressions, Input/Output statements, Assignment statements, Decision making statements, Switch statement, Looping statements, Pre-processor directives, Compilation process.

UNIT II

Introduction to Arrays: Declaration, Initialization, one dimensional array, Two dimensional array, String operations: length, compare, concatenate, copy, Selection sort, linear and binary search.

UNIT III

Introduction to functions: Function prototype, function definition, function call, Built-in functions (string functions, math functions), Recursion, Pointers, Pointer operators, Pointer arithmetic, Arrays and pointers, Array of pointers, Parameter passing: Pass by value, Pass by reference.

UNIT IV

Structure, Nested structures, Pointer and Structures, Array of structures, Self-referential structures, Dynamic memory allocation. Files, Types of file processing: Sequential access, Random access, Command line arguments.

TEXT BOOKS

1. Balagurusamy E., *Programing in C*, Mc-Graw Hill Education, 6th edition, 2010.
2. Kanetkar Y. P., *Let us C*, BPB publications, 2017.

REFERENCE BOOKS

1. Goel A. and Mittal A., *Computer Fundamentals and Programming in C*, Pearson Education, 2011.
2. Gottfried B. S., *Schaum's Outline of Theory and Problems of Programming with C*, Mc-Graw Hill Education, 1996.
3. Kernighan B.W. and Ritchie D.M, *The C Programming language*, 2nd edition, Pearson Education, 2006.
4. Thareja R., *Programming in C*, 2nd edition, Oxford University Press, 2016.

M.Sc. MATHEMATICS SEMESTER I

CODE: MATH21-706

SUBJECT NAME: PROGRAMMING IN C (LAB)

NO. OF CREDITS: 2

SESSIONAL : 30

L	T	P		
			FINAL EXAM	: 70
0	0	4	TOTAL	: 100

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: work with C desktop.
CO2: understand fundamental operations in C and write basic programs.
CO3: understand about arrays.
CO4: understand about structure.

List of Programs

1. Write a program to add, subtract, multiply and divide two numbers using menu driven program.
2. Write a program to find the largest among three numbers. (Using if-else statement).
3. Write a program to find the largest number out of ten numbers (using for- statement).
4. Write a program to find the average male height & average female heights in the class (input is in the form of sex code, height).
5. Write a program to find roots of quadratic equation.
6. Write a program using arrays to find the largest and second largest number out of given 10 numbers.
7. Write- a program to read a number and write it in reverse order.
8. Write a program to add and subtract two matrices.
9. Write a program to multiply two matrices.
10. Write a program to check that the input string palindrome or not.
11. Write- a program to read a string and write it in reverse order.
12. Write a program to concatenate two strings.
13. Write a program to calculate the length of the string.
14. Write a program to find factorial of a number using function.
15. Write a program using structure to enter a list of books, their prices and number of pages.

TEXT BOOKS

1. Kanetkar Y. P., *Let us C*, BPB Publishers, 15th edition. 2016.
2. Kenneth A., *C problem solving and programming*, Prentice Hall.

REFERENCE BOOKS

1. Gottfried B., *Programming with C*, Schaum Series, McGraw Hill Education, 4th edition, 2018.
2. Kernighan B.W. and Ritchie D.M., *Programming Language*, Pearson Education, 2nd edition, 2015

M.Sc. MATHEMATICS SEMESTER II
CODE: MATH21-751
SUBJECT NAME: MATHEMATICAL STATISTICS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: formulate and analyze discrete and continuous random variable, concept of joint, marginal and conditional distributions, and concept of mathematical expectations.
CO2: learn about various types of distributions (discrete and continuous) and their properties, Chebyshev's inequality, Weak law of large number.
CO3: learn testing of hypothesis, types of error and test of significance for large sample.
CO4: learn about small sampling test and Gamma and Exponential distributions.

UNIT - I
Random variable and probability functions: definition and properties, Discrete and continuous random variables, probability mass and density function, Two-dimensional random variable, joint, marginal and conditional distribution, Mathematical expectation and its properties, Moment generating function: definition and their properties.

UNIT - II

Discrete Distributions, Uniform and Bernouli distribution (definition only), Binomial Distribution: definition and their properties, Poisson Distribution: definition and their properties. Continuous Distribution, Normal Distribution: definition, Properties of Normal Distribution, Area under Normal Probability Curve, Importance of normal distribution, Chebyshev's inequality, Weak law of large number, Central limit theorem.

UNIT – III

Testing of Hypothesis: Parameter and Statistic, null and alternate hypothesis, Simple and Composite hypothesis, Critical region, Level of Significance, One tailed and two tailed test, two types of error.

Test of Significance: Large sample test for single mean, single proportion, difference between two means and two proportions.

UNIT - IV

Gamma distribution and their properties, Exponential distribution and their properties, Sampling distribution: chi –square test (Goodness of fit test, Independence of Attributes), t- test (for single mean, for difference of mean), F-test (for equality of two population variances).

TEXT BOOKS

1. Gupta,S.C and Kapoor V.K., *Fundamentals of Mathematical Statistics*, S. Chand Pub., New Delhi.
2. Baisnab and Jas, M., *Element of Probability and Statistics*, Tata McGraw Hill.

REFERENCE BOOKS

1. Freund J.E., *Mathematical Statistics*, Prentice Hall of India.
2. Hogg, R.V. and Craig, A.T., *Introduction to Mathematical Statistics*, Pearson Education Limited-2014.
3. Speigel, M., *Probability and Statistics*, Schaum Outline Series.
4. A.M. Mood, F.A. Graybill, and D.C. Boes, *Introduction to the theory of Statistics*, McGraw Hill Book Company.

M.Sc. MATHEMATICS SEMESTER II

CODE: MATH21-752

SUBJECT NAME: LINEAR ALGEBRA
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to understand:

CO-1: Dual space, Dual basis, Bidual spaces, Eigen values and Eigenvectors, Diagonalization
CO-2: Jordon Canonical form and Rational Canonical form.
CO-3: Inner product spaces, Orthogonality and orthonormality.
CO-4: Gram-Schmidt orthogonalization process, Inner product space isomorphism
CO-5: Bilinear forms and matrices, alternating bilinear forms, Rank of a quadratic form, Hermitian forms, Matrix representation of a Hermitian form

UNIT I

Dual spaces, Dual basis, Second dual space, Annihilators, Characteristic polynomial, Cayley-Hamilton theorem, Diagonalization, Eigenvalues and Eigenvectors, Algebraic and Geometric multiplicity of an eigenvalue, Minimal polynomial, Characteristic and minimal polynomial of block matrices.

UNIT II

Canonical forms: Triangular form, Invariance, Invariant-direct sum decompositions, Primary decomposition, Normal form, Nilpotent operators, Jordon Canonical form, cyclic subspaces, Rational Canonical form, Raw and column space of a matrix, Quotient Space.

UNIT – III

Inner product space: Inner product spaces, Orthogonality and orthonormality, Orthogonal expansion, Adjoint of a linear transformation, self-adjoint transformation, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalization process, Inner product space isomorphism, Complex

inner product space, Unitary operator, Normal operator, positive operator, Invariance and reducibility in inner product space.

UNIT-IV

Bilinear, Quadratic and Hermitien forms: Bilinear forms, Bilinear forms and matrices, Alternating bilinear forms, Symmetric bilinear forms, Real symmetric bilinear forms, Quadratic forms, Law of inertia, Orthogonal diagonalization of the quadratic form, Conversion of a symmetric matrix into quadratic form, rank of a quadratic form, Hermitian forms, Matrix representation of a Hermitian form.

TEXT BOOKS

1. Lipschutz S. and Lipson M., *Schaum's Outline of Linear Algebra*, McGraw Hill, India, 2004.
2. Halmos P.R., *Linear Algebra withProblems*. Mathematical Association of America, 2013
3. Pundir S.K., *A competitive approach to Linear Algebra*, CBS Publishers & Distributors, 2015

REFERENCE BOOKS

1. Andrilli S. and Hecker D, *Elementary Linear Algebra*, Academic Press, 2012.
2. Kolman B and Hill D. R., *Introductory Linear Algebra with Applications*, Pearson Education, 2003.
3. Hoffman K. & Kunze R., *Linear Algebra*, Second Edition, Pearson Education, 2002

M.Sc. MATHEMATICS SEMESTER II

CODE: MATH21-753

SUBJECT NAME: MATHEMATICAL METHODS

NO. OF CREDITS: 4

SESSIONAL : 25

L T P FINAL EXAM : 75

4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO 1: understand Co-ordinate Transformation and orthogonal co-ordinates
CO 2: understand Fourier series and able to apply Fourier transform
CO 3: apply Maline and Hankel transforms
CO 4: solve problems based on Bessel's and Legendre's functions

UNIT-I
Curvilinear Co-ordinates: co-ordinate transformation, orthogonal co-ordinates, change of co-ordinates, cartesian, cylindrical and spherical coordinates, expressions for velocity and acceleration ds, dv and ds2 in orthogonal coordinates, area, volume and surface area in cartesian, cylindrical and spherical coordinates in few simple cases, gradient, divergence, curl, Laplacian in orthogonal co-ordinates, contravariant and co-variant components of a vector, metric coefficients and the volume element.

UNIT-II
Fourier Series: Periodic Functions, Euler's formulae for Fourier series, Fourier series for discontinuous functions, half range series, Parseval's identity, Fourier integral theorem.
Fourier Transform: Definition and properties, Fourier transform of some elementary functions, convolution theorem, application of Fourier transforms to solve ordinary and partial differential equation.

UNIT – III
Mellin Transform: Definition, elementary properties, Mellin transform of derivatives, Integrals, Inverse Mellin transform, Convolution theorem, Inverse Mellin transform of two functions.
Hankel Transform: Definition, Elementary properties, Hankel transform of derivatives, Exponential functions, Inversion formula for Hankel transformation, Parseval's theorem, relation between Hankel and Laplace transform.

UNIT-IV
Bessel's functions, Bessel function of second kind of order n, Trigonometric expansion involving Bessel Functions, Bessel Integral, Fourier-Bessel Expansion, ber and bei function.

Legendre's associated functions and differential equation, integral expression for associated Legendre polynomial, recurrence relation for associated Legendre polynomial.

TEXT BOOKS

1. Sneddon, I. N., *The Use of integral Transforms*, McGraw Hill, 1972
2. Bell W. W., *Special Functions for Scientists and Engineers*, Courier Corporation, 2004
3. Spiegel M., Lipschutz S., Spellman D., *Vector Analysis*, Schaum's Series 2011.

REFERENCE BOOKS

1. Goyal S.P., Goyal A.K., *Integral Transforms and its Applications*, Jaipur Publishing House, 2014.
2. Raisinghania M.D., *Ordinary Differential Equations*, S. Chand & Co., New Delhi, 2013

M.Sc. MATHEMATICS SEMESTER II
CODE: MATH21-754
SUBJECT NAME: NUMERICAL METHODS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: apply various mathematical operations to find out solutions of algebraic and transcendental equations.
CO2: find Solution of simultaneous algebraic equations and to solve the problems based on Numerical differentiation and integration.

CO3: find Numerical solution of Ordinary differential equations.
CO4: find Numerical solution of partial differential equations.

UNIT-I

Solution of algebraic and transcendental equations: Bisection method, Newton's Raphson method. Solution of simultaneous algebraic equations: Gauss Elimination method, Gauss Jordon method, LU decomposition method, Jacobi's method, Gauss-Seidal method, Relaxation method. Curve fitting: Least square curve fit- Straight line fitting, parabolic curve fitting, fitting of exponential curve.

UNIT-II

Langrage's interpolation formula and Newton 's divided difference formulae.
Numerical differentiation and integration: Formula for derivatives, Trapezoidal rule, Simpson's 1/3rd and 3/8th rules, Boole's rule and Weddle's rule, Gaussian and Romberg's Integration.

UNIT-III

Numerical solution of O.D.E.: Taylor series, Picard's method, Euler's Method, Modified Euler method, Runge-Kutta second and fourth order methods, predictor collector methods (Adams-Bash forth and Milne's method only). Finite element method for finding approximate solution of boundary value differential equation problems.

UNIT-IV

Numerical solution of P.D.E.: Finite difference approximations of partial derivatives, solution of Laplace equation (Standard 5-point formula only), one-dimensional heat equation (Schmidt method, Crank-Nicolson method, Dufort and Frankel method) and wave equation.

TEXT BOOKS

1. K. Atkinson and W. Han, *Elementary Numerical Analysis*, John Wiley, 2006.
2. S.S. Shastri, Introductory *Methods of Numerical Analysis*, PHI learning pvt. Ltd., 2012
3. B.S. Grewal, Numerical *Methods in Engineering & Science*, Khanna publications, 2014

REFERENCE BOOKS

1. H.C. Taneja, *Advanced Engineering Mathematics*, IK International, New Delhi, 2013
2. M.K. Jain, S.R.K. Iyenger and R.K. Jain, *Numerical Methods for Scientific and Engineering. Computations,* Wiley Eastern Ltd., 1985.

M.Sc. MATHEMATICS SEMESTER II
CODE: MATH21-755
SUBJECT NAME: PROGRAMMING IN C++
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Distinguish between Structured and Object-Oriented problem-solving approaches and apply them based on the problem given
CO2: Define the fundamental concepts in programming with C++.
CO3: Identify classes and objects from the given problem description and able to create c classes and objects using C++
CO4: Achieve code reusability and extensibility by means of Inheritance and Polymorphism.

Unit–I
Object Oriented Programming Paradigm, Basic Concepts of Object-Oriented Programming, Benefits of Object-Oriented Programming, Object Oriented Languages, Applications of Object-Oriented Programming, Beginning with C++. Tokens, Keywords, Identifiers and **hg**Constants, Data Types, Type Compatibility, Variables, Operators in C++, Implicit Conversions, Operator Overloading, Operator Precedence, Control Structures.

Unit –II Functions, pointer to members.

Unit-III
Constructors, Parameterized Constructors, Copy Constructors, Dynamic Constructors, Destructors, Defining Operator Overloading, Overloading Operators, Rules for Overloading Operators, Type Conversions. Inheritance, derived class and their constructs, overriding member function, class hierarchies, Public and Private inheritance levels, Polymorphism

UNIT-IV

Pointers, Pointers to Objects, this pointer, Pointer to Derived Classes, Virtual Functions, Class for File stream operations, opening and closing a file. File pointers and their manipulations, Sequential input and output operations, Random Access, Error handling during file operations, Command–line argument.

TEXT BOOKS

1. Balagurusamy E, *Object Oriented Programming with C++*, Tata McGraw- Hill Publishing Company limited, Fourth Edition, 2008.

2. Baarkakati N., *Object Oriented Programming in C++*, Prentice Hall of India, 1997.

REFERENCE BOOKS

1. Dewhurst, Stephen C.,Kathy T. Stark. *Programming in C++*. Prentice-Hall, Inc., 1989.
2. Bjanne Stroustrup, *The C++ Programming Language*, Addison Wesley, 4th Edition, 2013.
3. Herbert Schildt, *C++ The Complete Reference*, Tata Mc Graw- Hill Edition, 2003.
4. Stanley, B.Lippman, Josee Lajoie, *C++Primer*, 3rd Edition, Addison Wesley, 1998

M.Sc. MATHEMATICS SEMESTER II

CODE: MATH21-756

SUBJECT NAME: PROGRAMMING IN C++ (LAB)

NO. OF CREDITS: 2

			SESSIONAL	: 30
L	T	P	FINAL EXAM	: 70
0	0	4	TOTAL	: 100

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: analyze performance of algorithms.
CO2: choose the appropriate data structure and algorithm design method for a specified application.
CO3: implement two-dimensional array operations.
CO4: implement of stack and queue using array.

List of Programs

1. Write a class to represent a vector (a series of float values). Include member functions to perform the following tasks: To create the vector, To modify the value of a given element, To multiply by a scalar value, To display the vector in the form (10, 20, 30, …). Write a program to test your class.
2. Create a class FLOAT that contains one float data member. Overload all the four arithmetic operators so that they operate on the objects of FLOAT.
3. Write a program which shows the days from the start of year to date specified. Hold the number of days for each month in an array. Allow the user to enter the month and the day of the year. Then the program should display the total days till the day.
4. Write a program to include all possible binary operator overloading using friend function.
5. Write a program to read an array of integer numbers and sort it in descending order. Use read data, put data, and array as member functions in a class.
6. Write a program to read two-character strings and use the overloaded '+' operator to append the second string to the first.
7. Develop a program Railway Reservation System using Hybrid Inheritance and Virtual Function.
8. Using overloaded constructor in a class write a program to add two complex numbers.
9. Create a class MAT of size (m, n). Define all possible matrix operations for MAT type objects.

10. Write a program that determines whether a given number is a prime number or not and then prints the result using polymorphism.
11. Write a program to illustrate the dynamic initialization of constructors.
12. Write a program to illustrate the use of pointers to objects.
13. Write a program to illustrate how to construct a matrix of size m x n.
14. Write a program to arrange the given data in ascending/descending order using various sorting algorithms.
15. Write a program to find the biggest/smallest number in the given data using various search algorithms.

TEXT BOOKS

1. Balagrusamy E., *Object Oriented Programming with C++*, 2nd Edition, Tata McGraw Hill Pub. Co.

REFERENCE BOOKS

1. Robert L. I. S., *Object Oriented Programming using C++*, Waite's Group Galgotia Pub.
2. Gottfried B. S., Object Oriented Programming using C++, Schaum's Outline Series, Tata McGraw Hill Pub. Co.
3. Barakaki J. N., *Object Oriented Programming using C++*, Prentice Hall of India, 1996

M.Sc. MATHEMATICS SEMESTER III
CODE: MATH21-801
SUBJECT NAME: TOPOLOGY
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1. Determine interior, closure, and boundary points, limit points of subsets and basis and sub basis of topological spaces.
CO2. Check whether a collection of subsets is a basis for a given topological spaces or not, and determine the topology generated by a given basis.
CO3. Identify the continuous maps between two spaces and maps from a space into product space and determine common topological property of given two spaces.
CO4. Determine the connectedness and path connectedness of the product of an arbitrary family of spaces.
CO5. Find Hausdorff spaces using the concept of net in topological spaces and learn about 1st and 2nd countable spaces, separable and Lindelöf spaces. Understand Urysohn's lemma, Tietze's extension theorem, Urysohn's metrization theorem

UNIT - I

Topological spaces, basis and sub basis, ordered topology, quotient topology, product topology, Limit points, adherent points, Derived sets, Closure, interior, exterior and boundary points of a set, subspace.

UNIT - II

Continuity, homeomorphism, countability axioms, first and second countable spaces, Separable space

Connectedness: connected sets, component, path component, local connectedness, disconnected sets, Totally Disconnected sets, locally connected spaces.

UNIT - III

Compact spaces; limit point compact and sequentially compact spaces, local compactness and one-point compactification, finite product of compact spaces, Tychonoff's theorem (without proof)

UNIT -IV

Separation axioms (T0, T1, T2, T3 spaces, Regular space, completely regular spaces, Normal spaces), their characterizations and basic properties, Urysohn's lemma, Statement of Tietze's extension theorem, statement of Urysohn's metrization theorem.

TEXT BOOKS

1. Munkres J. R. Topology, Second Edition, Pearson, 2015.
2. Singh T.B., Elements of Topology, CRC Press, Taylor & Francis, 2013

TEXT BOOKS

1. Kelley J.L., General Topology, Dover Publications, 2017.
2. Willard S., General Topology, Dover Publications, 2004.

M.Sc. MATHEMATICS SEMESTER III
CODE: MATH21-802
SUBJECT NAME: MECHANICS AND CALCULUS OF VARIATIONS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Understand generalized coordinates, constraints, Lagragian equation.
CO2: Understand Hamiltonian formulation and Poisson bracket and related problems.
CO3: Understand rigid body dynamics and variation of a functional and its properties.
CO4: Solve fundamental problems of calculus of variations and variational problems with moving boundaries

UNIT I
Constraints and their classification: Scleronomic and rheonomic, holonomic and non-holonomic dynamical systems, conservative and dissipative; Virtual work: virtual displacement, principle of virtual work; D'Alembert's principle and its applications; Lagrangian formulation: Degrees of freedom, generalized coordinates, generalized force, generalized velocity, expression of kinetic energy using generalized velocity, Lagrange's equation of motion and simple applications, cyclic coordinates, generalized momenta, conjugate momenta.

UNIT II
Hamiltonian formulation- Legendre's dual transformations and its extension to include passive variables, Hamilton's function and Hamilton's equations of motion, properties of Hamiltonian, simple applications of the Hamiltonian equations of motion; Routhian function; canonical

transformation, properties of generator functions, Poisson bracket: Jacobi identity for Poisson bracket, Poission's theorem, Hamilton's equation in Poisson bracket, invariance of Lagrange and Poisson brackets under canonical transformation.

UNIT III

Central force, equivalent one-body problem, moments and product of inertia, theorems of perpendicular and parallel axis, angular momentum of a rigid body about a fixed point and about fixed principal axes, Euler's dynamical equations for motion of rigid body; Variation of a functional and its properties, fundamental lemma of calculus of variations, Euler's equation for one dependent function and its different forms, Motivational problems of calculus of variation: Shortest distance in a plane, minimum surface of revolution, Brachistochrone problem.

UNIT IV

Geodesics, variational problems for functionals involving several dependent variables and higher order derivatives, functional involving functions of several independent variables, isoperimetric problems; Variational problems with moving boundaries- One end point are fixed and the other is movable, both the end points movable, variational problem with a moving boundary for a functional dependent on two functions; Hamilton's principle and principle of least action, difference between these principles, solving problems using these principles, Lagrange's equation from Hamilton's principle and vice-versa.

TEXT BOOKS

1. Goldstein H., Poole C. and Safko J., *Classical Mechanics*, 3rd edition. Pearson Publications, New Delhi, 2011
2. Chorlton F., *Text book of Dynamics*. CBS Publishers, Reprint, 2002
3. Elsgolts, L., *Differential Equations and the Calculus of Variations*. University Press of the Pacific, 2003

REFERENCE BOOKS

1. Andrilli Rana N.C. and Joag P.S., *Classical Mechanics*. McGraw Hill Education, Chennai, 2016.
2. Grantmacher F., *Lecture in analytical Mechanics*. Mir Publication, 1975.
3. Fox C., *An Introduction to the Calculus of Variation*. Dover Publications, New York,1987.
4. Raisinghania M.D., *Advanced Differential equations*. S. Chand Publications, New Delhi, 1998.

M.Sc. MATHEMATICS SEMESTER III

CODE: MATH21-803

SUBJECT NAME: PARTIAL DIFFERENTIAL EQUATIONS

NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: Classify partial differential equations and solve boundary value problems related to Laplace, Heat and wave equations in one, two and three dimensions.

CO2: Establish a fundamental familiarity with homogeneous and non-homogeneous transport equation; also learn fundamental solution of Laplace equation.

CO3: Familiarize themselves with Green's Function, Heat equation; uniqueness and solution.

CO4: Learn about Kirchhoff's and Poisson formula, uniqueness of wave equation.

UNIT-I

Method of separation of variables to solve B.V.P. associated with one dimensional heat equation, heat equation in semi-infinite and infinite regions. Solution of three-dimensional Laplace equation in Cartesian, cylindrical and spherical coordinates. Solution of Wave equation in two dimensions and three dimensions (Cartesian, Cylindrical, Spherical).

UNIT-II

Partial Differential Equation of k^{th} order: Definition, examples and classifications, Initial value problems, Transport equations: definition, solution of homogeneous and non-homogeneous transport equations, Laplace Equation, Fundamental solution of Laplace equation, Harmonic function, Mean Value formula for Harmonic function

UNIT-III

Green's formula, Corrector function, Green's function and its derivation, Representation formula using Green's function, Symmetry of Green's function, Energy methods: uniqueness, Dirichlet's Principle.
Heat Equations: Fundamental solution of Heat equation, Uniqueness of Heat Equation: Energy methods.

UNIT-IV

Wave equation: Physical interpretation, solution for one dimensional wave equation, Reflection method, derivation of Euler-Poisson-Darboux equation, Kirchhoff's and Poisson's formulas (for only), solution of non-homogeneous wave equation for . Energy method, uniqueness of solution.

TEXT BOOKS

1. Peter V. O'Neil, Advanced Engineering Mathematics, ITP
2. Evans L.C., *Partial Differential Equations,* Graduate Studies in Mathematics) 2nd Edition, American Mathematical Society,2014
3. Sneddon I.N., *Elements of Partial Differential Equation,* McGraw Hill, New York.

REFERENCE BOOKS

1. Weinberger H. F., *A First Course in Partial Differential Equation*, John Wiley &Sons, 1965.
2. Amarnath T., *An Elementary Course in Partial Differential Equations*, Jones & Bartlett, 2009

M.Sc. MATHEMATICS SEMESTER III
CODE: MATH21-804
SUBJECT NAME: OPERATIONS RESEARCH
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: Solve linear programming problems using simplex methods and its modified types.
CO2: Solve linear programming problems using simplex methods and its modified types
CO3: Implement games theory and have an understanding of sequencing.
CO4: understand and apply various techniques of operation research.

UNIT-I

The origin of OR, Definition and scope of Operation Research, Types, methodology and typical applications of OR, Phases of an O.R. study, Formulation of Linear-programming model, graphical solution, converting the linear programming problem to standard form, Simplex method.

Big-M method, two-phase method, degeneracy, alternate optima, unbounded and infeasible solution, definition of the dual problem, prima-dual relationship, Dual Simplex method.

UNIT-II

Assignment problem and its mathematical formulation, solution of assignment problem (Hyngarian method), Transportation problem and its mathematical formulation. Initial basic feasible solution of transportation problem by North-West corner rule. Lowest-Cost Entry method and Vogel's Approximation method, Optimal solution of transportation problem (Modi method).

UNIT-III

Game theory: Two person zero games, Minimax and maximum principle, Game with saddle point, Rule of dominance, Algebraic and graphical method, Sequencing problem – processing through 2 machines, 3 machine – s jobs and k machines.

UNIT-IV

Queuing Models :Introduction of Basic Concepts in Stochastic Processes. Markov Chain and Markov Processes. Queuing Systems. Probability Distribution of Arrival and Service Times. Markovian Queuing Systems: M/M/1, M/M/C, M/M/1/N, M/M/C/N

TEXT BOOKS

1. Sharma, S.D., Operation Research, Kedar Nath Ram Nath Publications
2. Sharma, J.K., Mathematical Model in Operation Research, Tata McGraw Hill

REFERENCE BOOKS

1. Taha, H.A., Operation Research-An introduction, Tata McGraw Hill, New Delhi.
2. Gupta, P.K. and Hira, D.S., Operations Research, S. Chand & Co.

M.Sc. MATHEMATICS SEMESTER III
CODE: MATH21-805A
SUBJECT NAME: MECHANICS OF SOLIDS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: understand concept of tensors; Gradient, Divergence and Curl in Tensor notations.
CO2: understand strain tensor and its various concepts.
CO3: understand stress tensor and principal stresses.
CO4: derive and understand Generalized Hooke's Law.

UNIT I

Summation convention, coordinate transformation, cartesian tensor of various orders, algebra of tensors, contraction, symmetric and skew-symmetric tensor, Kronecker delta, Alternating tensor, Gradient, Divergence, Curl in tensor notations, Gauss-divergence theorem, partial derivatives, contravariant and covariant tensors.

UNIT II

Deformation in elastic bodies, homogeneous strain and its properties, Affine transformation, infinitesimal affine transformation, geometric interpretation of components of strain, strain

quadric of Cauchy, strain-displacement relations, Strain invariants, principal direction and principal strain, homogeneous deformation.

UNIT III

Stress vector and stress tensor, symmetry of stress tensor, stress quadric of Cauchy, equation of equilibrium and motion, principal stresses.

UNIT IV

Generalized Hooke's Law- relation between stress and strain, Elastic constants and their physical significance, strain energy function and its connection with Hooke's Law, Beltrami-Michell compatibility equations.

TEXT BOOKS

1. Chandrasekharaiah, D. S. and Debnath, L. *Continuum Mechanics*, Academic Press Inc., San Diego, CA, 1994.
2. Narayan, Shanti. *A text book of Cartesian Tensors (with an introduction to general tensors),* 3rd edition. New Delhi: S. Chand Publications, 1968

REFERENCE BOOKS

1. Young, E. C., *Vectors and tensor analysis*, 2nd edition, 1993.
2. Kolsky, H., *Stress waves in Solids*. Dover Publications, 1963.
3. Ghosh, P. K., *Mathematics of waves and vibrations*. New Delhi: The Macmillan Company of India Limited, 1975.
4. Timoshenko S. and Goodier N., *Theory of Elasticity,* McGraw Hill, New York, 1970.
5. Fung Y.C., *Foundations of Solid Mechanics*, Prentice Hall, New Delhi

M.Sc. MATHEMATICS SEMESTER III

CODE: MATH21-805B

SUBJECT NAME: ANALYTICAL NUMBER THEORY

NO. OF CREDITS: 4

SESSIONAL : 25

L	T	P		
			FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: understand various types of primes, Mersenne numbers and Farey series.
CO2: understand primitive roots and quadratic residue.
CO3: understand Diophantine equations of various types
CO4: have complete knowledge of various arithmetic functions.

UNIT I
Distribution of primes, Fermat and Mersenne numbers, Farey series and some results concerning Farey series, Approximation of irrational numbers by rationals, Hurwitz's theorem, Irrationality of and .

UNIT II
The arithmetic in Zn, The group Un, Primitive roots and their existence, the group Upn (p-odd) and U2n, The group of quadratic residues Qn, Quadratic residues for prime power moduli and arbitrary moduli, The algebraic structure of Un and Qn.

UNIT III
Riemann Zeta Function and its convergence, Application to prime numbers, Riemann Zeta as Euler product, Evaluation of Zeta (2) and Zeta (2k). Diophantine equations and The representation of number by two or four squares, Waring problem, Four square theorem

UNIT IV
Arithmetic functions Definitions, examples and simple properties of arithmetic functions, Perfect numbers, Mobius inversion formula, The Mobius function.

TEXT BOOKS

1. Hardy G. H. and Wright E. M., *An Introduction to the Theory of Numbers,* Oxford University Press, 2008
2. Gareth A. Jones and Jones J. M., *Elementary Number Theory*, Springer Edition, 1998

3. McCoy N. H., *The Theory of Numbers*, McMillan Company Limited, 1965

REFERENCE BOOKS

1. Burton D. M., *Elementary Number Theory,* McGraw Hill, 2017
2. Niven I. and Zuckermann H. S., *An Introduction to the Theory of Numbers*, John Wiley & Sons, 1991.

M.Sc. MATHEMATICS SEMESTER III
CODE: MATH21-805C
SUBJECT NAME: ADVANCED COMPLEX ANALYSIS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Understand the basics of logarithmically convex function that helps in extending maximum modulus theorem.
CO2: Understand the metric on the spaces of meromorphic and analytic functions.
CO3: Develop the understanding of harmonic function theory.
CO4: Develop the understanding of entire functions.

UNIT I

Convex functions, Hadamard's three circles theorem, Phragmen-Lindelöf theorem, Spaces of continuous functions, Arzela-Ascoli theorem, Spaces of analytic functions, Hurwitz's theorem, Montel's theorem, Spaces of meromorphic functions.

UNIT II

Integral functions, Riemann mapping theorem, Weierstrass factorization theorem, Factorization of sine function, Runge's theorem, Simply connected regions, Mittag-Leffler's theorem.

UNIT III

Analytic Continuation, Harmonic functions, Maximum and minimum principles, Harmonic function on a disk, Harnack's theorem, Subharmonic and superharmonic functions, Maximum and minimum principles, Dirichlet's problems, Green's function.

UNIT IV

Entire functions, Jensen's formula, Bloch's theorem, The Little Picard theorem, Schottky's theorem, The Great Picard theorem.

TEXT BOOKS

1. Conway J. B., *Functions of one Complex variable*, 2nd edition, Narosa, New Delhi, 1996.
2. Priestly H. A., Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.

REFERENCE BOOKS

1. Rudin W., *Real and Complex Analysis*, 3rd edition, Mc Graw Hill, 1987.
2. Ahlfors L. V., *Complex Analysis*, 3rd Edition, Mc Graw Hill Co., Indian Edition, 2017.
3. Hahn L., Epstein B., *Classical Complex Analysis*, Jones and Bartlett, 1996

M.Sc. MATHEMATICS SEMESTER III

CODE: MATH21-806

SUBJECT NAME: MATLAB

NO. OF CREDITS: 2

			SESSIONAL	: 30
L	T	P	FINAL EXAM	: 70
0	0	4	TOTAL	: 100

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: work with MATLAB desktop
CO2: become familiar with fundamental operations in MATLAB and write basic programs.
CO3: generate plots and export this for use in their reports.
CO4: write codes for various numerical methods.

List of Programs

1. Operating MATLAB desktop.
2. Matrix operation (addition, multiplication, inverse, transpose etc.).
3. Plotting of graphs of function basic functions like and to illustrate the effect of and on the graph.
4. WAP to check whether a number is even or odd
5. WAP to find greatest among ten numbers
6. WAP to draw graph of ellipse
7. WAP to find root of an equation using Bisection Method
8. WAP to find root of an equation using Regula Falsi Method
9. WAP to find root of an equation using Secant Method
10. WAP to find root of an equation using Newton Raphson Method
11. WAP to solve system of equations using Gauss Jacobi Method
12. WAP to evaluate integral using Trapezoidal rule.
13. WAP to evaluate integral using Simpson's 1/3 Rule
14. WAP to evaluate integral using Simpson's 3/8 Rule
15. WAP to evaluate integral using Boole's rule
16. WAP to evaluate integral using Weddle's Rule
17. WAP for Lagrange's Interpolation formula
18. WAP to solve differential equation using Euler's Method
19. WAP to solve differential equation using Runge Kutta Method

TEXT BOOKS

1. Pratap R., *Getting Started with MATLAB*, Oxford University Press, New Delhi, 2015.
2. Mathews J. H. and Kurtis D. F., *Numerical Methods using MATLAB*, *4th edition*, PHI Learning Pvt. Ltd., New Delhi, 2012.

REFERENCE BOOKS

1. Alam S. N. and Alam S. S., *Understanding MATLAB: A Textbook for Beginners*, I K International Pub., 2013.
2. Chapman S.J., *MATLAB Programming for Engineers*, 4th Edition, Cengage Learning, Boston. 2015.

M.Sc. MATHEMATICS SEMESTER IV
CODE: MATH21-851
SUBJECT NAME: FUNCTIONAL ANALYSIS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Understand convergence of operators by using a suitable norm, compute the dual spaces.
CO2: Describe weak and strong convergence and uniform boundedness theorem, open mapping theorem and closed graph theorem.
CO3: Learn the properties of compact operators.
CO4: Classify operators into self-adjoint, unitary and normal operators

UNIT-I
Normed spaces, Banach spaces, Finite dimensional normed spaces and subspaces, Compactness and finite dimension, Bounded and continuous linear operators, Linear operators and functionals on finite dimensional spaces, Normed spaces of operators, Dual spaces.

UNIT-II

Hahn Banach theorems for real and complex normed spaces, Adjoint operator, Reflexive spaces, Uniform boundedness theorem strong and weak convergence, Convergence of sequences of operators and functionals, Open mapping theorem, Closed graph theorem.

UNIT-III

Hilbert spaces, Orthogonal complements and direct sums, Bessel's inequality, Total orthonormal sets and sequences, Representation of functionals on Hilbert spaces, Hilbert adjoint operators, Self-adjoint, unitary and normal operators.

UNIT-IV

Compact operator and its relation with continuous operator, Compactness of linear transformation on a finite dimensional space, Properties of compact operators, Compactness of the limit of the sequence of compact operators.

TEXT BOOKS

1. Kreyszig E., Introductory Functional Analysis with Applications, John Wiley & Sons, India, 2006.
2. Simmons George F., Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.

REFERENCE BOOKS

1. Bachman G. and Narici L., Functional Analysis, Dover Publications, 2000.
2. Bhatia R., Notes on Functional Analysis, Hindustan Book Agency, India, 2009.
3. Schechter M., Principles of Functional Analysis, Second Edition, American Mathematical Society, 2001.

M.Sc. MATHEMATICS SEMESTER IV

CODE: MATH21-852

SUBJECT NAME: DIFFERENTIAL GEOMETRY

NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: Explain and apply the concepts and techniques of differential geometry of curves and surfaces

CO2: Analyze and solve problems (using concepts and techniques from differential geometry)

CO3: Parametrize a plane and a space curve and to calculate its curvatures and Frenet-Serret apparatus and arc-length

CO4: Understand Conjugate directions, Conjugate system, Geodesic Properties.

UNIT-I

Curves with Torsion: Tangent, Principal normal, Curvature, Binormal, Torsion, Serret-Frenet formulae, Locus of centre of curvature, Spherical curvature, Locus of Centre of spherical curvature, Involutes, Evolutes

UNIT II

One-parameter family of surfaces, Envelope. Characteristics, Edge of regression, Developable surfaces. Developables associated with a curve, osculating developable, Polar developable, Rectifying developable, two-parameter family of surfaces: Envelope. Characteristic points, Envelopes, Edge of regression, Ruled surface, Developable surface, Monge's theorem, conjugate directions.

UNIT III

Curvilinear coordinates, First order magnitudes, Directions on a surface, The normal Second order magnitudes, Derivatives of n , Curvature of normal section, Meunier's theorem, Principal directions and curvatures, First and second curvatures, Euler's theorem, Dupin's indicatrix, The surface z = f(x,y), Surface of revolution.

UNIT IV

Conjugate system: Conjugate directions, Conjugate system Asymptotic lines, asymptotic lines, Curvature and torsion, Isometric lines: Isometric parameters, Null lines, or minimal curves, Geodesic Property, Equations of geodesics, Surface of revolution, Torsion of a geodesic.

TEXT BOOKS

1. Goetz Abraham; Introduction to Differential Geometry: Addison Wesley Pub. Company
2. Wetherburn C.E., Differential Geometry of 3- Dimentions, Cambridge University Press.

REFERENCE BOOKS

1. Prakash Nirmala, Differential Geometry an Integrated Approach, McGraw-Hill
2. Neill B.O., Elementary Differential Geometry, Academic Press.
3. Willmore T.J., An introduction to Differential Geometry

M.Sc. MATHEMATICS SEMESTER IV
CODE: MATH21-853
SUBJECT NAME: FLUID DYNAMICS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: understand the streamlines, path lines, Equation of continuity and rigid boundaries.
CO2: apply Euler and Bernoulli's equation of motion, Potential Theorems.
CO3: understand the concept of sources, sinks and doublets.
CO4: understand complex velocity potentials, derive and apply Milne Thomson circle theorem, Blasius theorem.

UNIT I

Real fluids and ideal fluids, Velocity at a point, Eulerian and Lagrangian methods, Velocity potential, Vorticity vector, Local and particle rate of change, Streamlines, Path lines, Streak lines, Equation of continuity and related problems, acceleration of fluid, conditions at a rigid boundary.

UNIT II

Pressure at a point in a fluid at rest and in a moving fluid, Euler's equation of motion, Bernoulli's equation, Practical problems, Potential theorems, Flows involving axial symmetry, Stationary sphere in a uniform stream, Impulsive motion: Kelvin's theorem of circulation, Equation of vorticity.

UNIT III

Some three-dimensional flows: sources, sinks and doublets, Images of sources, sinks and doublets in rigid plane and in solid spheres, Stoke's stream function.

UNIT IV

Two dimensional flows, Complex velocity potential, Milne Thomson circle theorem and its applications, Two-dimensional sources, sinks, doublets and their images, Theorem of Blasius, Vortex rows, Karman vortex street.

TEXT BOOKS

1. Charlton, F. *Text Book of Fluid Dynamics*, GK Publishers, Reprint, New Delhi, 2009.
2. Raisinghania M.D., *Fluid Dynamics*. S. Chand Publications, New Delhi, 2010.

REFERENCE BOOKS

1. Landau, L. D., and Lifhshitz E. M., *Fluid Mechanics, 2nd Edition*. Pergamon Press Ltd., New-York, 1987.
2. Batchelor, G. K. *An Introduction to Fluid Mechanics*. Cambridge University Press, 1967.
3. Kundu P. K., and Cohen I. M., *Fluid Mechanics*. Harcourt (India) Pvt. Ltd., New Delhi, 2003.
4. Yuan S.W., Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976

M.Sc. MATHEMATICS SEMESTER IV
CODE: MATH21-854
SUBJECT NAME: INTEGRAL EQUATIONS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

After Successful completion of this course, students will be able to

CO1: understand the methods to reduce Initial value problems associated with linear differential equations to various integral equations.
CO2: categorize different integral equations and their various solution techniques.
CO3: describe importance of Green's function method and its use to solve boundary value problems
CO4: identify and solve singular integral equations

UNIT-I
Linear Integral equations, some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations, Resolvent kernel as a series, Laplace transform method for a difference kernel, Solution of a Volterra integral equation of the first kind, Convolution integral.

UNIT-II
Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations, Resolvent kernel as a sum of series, Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels, Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homogeneous Fredholm equations with degenerate kernels.

UNIT-III

Singular integral equation, solution of Abel integral equation, Cauchy principal value for integrals: Cauchy's general and principal values, Holder condition, singular integrals, Plemelj formulas, Poincare-Bertrand transformation formula, solution of Cauchy-Type singular integral equation, closed contour, unclosed contours, Riemann-Hilbert problem. Hilbert kernel, Hilbert formula, solution of Hilbert-type singular integral equation of first and second kind.

UNIT-IV

Green's function, use of method of variation of parameters to construct the Green's properties of the Green's function, Alternate procedure for construction of the Green's function by using its basic four properties, Green's function approach for IVP for second order equation, Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green's function.

TEXT BOOKS

1. Kanwal R.P., *Linear Integral Equations: Theory and Techniques,* New York: Birkhäuser, 2013.
2. Jerry A. J., *Introduction to Integral Equations with Applications*, 2nd edition, John Wiley & Sons, New York, 1999.
3. Lovitt W. V., *Linear Integral Equations*, McGraw Hill, New York

REFERENCE BOOKS

1. Raisinghania M. D., *Integral Equation of Boundary Value Problem*, S-Chand, 2016
2. Corduneanu C., *Integral Equations and Applications*, Cambridge: Cambridge University Press, 2008.

M.Sc. MATHEMATICS SEMESTER IV

CODE: MATH21-855A

SUBJECT NAME: ADVANCED OPERATIONS RESEARCH

NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: understand and use quantitative methods and technique for effective decision making.
CO2: model formulation and apply them in solving business.
CO3: understand sensitivity analysis and applications of linear programming.
CO4: Solve problem related to inventory using appropriate inventory models.

UNIT I

Sensitivity Analysis & Integer Linear Programming: Introduction of Sensitivity Analysis, Change in Objective function coefficient, Change in availability of resources, Addition of new variable and new constraint.

Introduction to Integer Linear Programming, Gomory's all integer cutting plane method, Gomory's mixed-integer cutting plane method, Branch and bound method, Application of Zero-One integer Programming.

UNIT II

Dynamic Programming: Bellman's Principle of optimality of Dynamic Programming, Multistage decision problem and its solution by Dynamic Programming with finite number of stages, Solution of linear programming problems as a Dynamic Programming problem

UNIT III

Inventory control models: Economic order quantity (EOQ) model with uniform demand, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.

UNIT IV

CPM and PERT: Common errors in network drawing, Rules for network construction, Fulkerson's Rule, Float and Network diagram, PERT computation, Critical Path Analysis, Estimation of Project Completion Time, Project crashing.

TEXT BOOKS

1. Sharma, S.D., *Operation Research*, Kedar Nath Ram Nath Publications.
2. Taha H.A., *Operation Research-An introduction*, Tata McGraw Hill, New Delhi

REFERENCE BOOKS

1. Sharma, J.K., *Mathematical Model in Operation Resear*ch, Tata McGraw Hill. S

2. Hillier S. and Lieberman G. J., *Introduction to Operations Research 8th edition,* Tata Mc Graw Hill, Singapore, 2004.
3. Gupta P K. and Hira D.S., *Operations Research*. S. Chand & Co, New Delhi.
4. Satty T. L., *Elements of Queueing Theory with Applications*, Dover, NY, 1983.
5. Hadley G., *Nonlinear and Dynamic Programming*, Addison-Wesley, 1964

M.Sc. MATHEMATICS SEMESTER IV
CODE: MATH21-855B
SUBJECT NAME: ADVANCED DISCRETE MATHEMATICS
NO. OF CREDITS: 4

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Understand partially ordered sets, generating function and solution of recurrence relations.
CO2: Understand lattices, properties of lattices and Boolean algebra, properties of Boolean algebra.
CO3: Understand graph theory
CO4: Understand about trees and spanning trees

UNIT I
Partially ordered sets, Hasse diagram, Isomorphism, ordered sets, Principle of Mathematical induction, Formal logic statements, Symbolic representations and Tautologies, Quantifiers, proposition logic. Generating functions, recurrence relations, Explicit formula for a sequence, solution of recurrence relations, homogenous recurrence relations with constant coefficients, particular solution of difference equation, recursive functions solution of a recurrence relations by the method of generating function.

UNIT II

Lattices- Lattices as partially ordered sets, their properties, Lattices as algebraic systems, some special lattices e.g., complete, complemented and distributive lattices

Boolean Algebra – Boolean Algebra as lattices, various Boolean identities, the switching algebra e.g., Toin-Irreducible elements, Atoms and Minterms, Boolean forms and their equivalence, Minterm Boolean forms, Sum of products canonical forms, minimization of Boolean functions.

UNIT III

Graph Theory- Definition of Graphs, special graphs, subgraphs, isomorphism of graphs, walk, Paths, Circuits, Euler's formula for connected planar graph, Complete and complete bipartite graphs Eulerian path and circuits, Hamiltonian circuits, matrix representation of graphs, planar graphs

UNIT IV

Directed graphs, weighted undirected graphs, coloring of graphs, trees, isomorphism of trees, indegree and outdegree of a vertex, spanning tree of a graph, shortest path problems, Minimal spanning tree, Prim algorithm, Kruskal's algorithm, tree searching.

TEXT BOOKS

1. Babu Ram, *Discrete Mathematics*, Pearson Publications.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 3rd Edition, Pearson Education (Singapore) Pte. Ltd., Indian Reprint 2018.

REFERENCE BOOKS

1. C.L. Liu, *Elements of Discrete Mathematics*, McGraw-Hill. 1985.
2. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 2002.

M.Sc. MATHEMATICS SEMESTER IV

CODE: MATH21-855C

SUBJECT NAME: MATHEMATICAL MODELING

NO. OF CREDITS: 4

SESSIONAL : 25

L	T	P		
			FINAL EXAM	: 75
4	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: understand various techniques of mathematical modeling.
CO2: apply mathematical model in different fields and situations.
CO3: understand mathematical modeling through partial differential equations.
CO4: understand Stochastic models and their need

UNIT I
Introduction and the technique of mathematical modeling, Classification and characteristics of mathematical models, Mathematical modeling through algebra, Finding the radius of the earth, Motion of planets, Motions of satellites, Linear and Non-linear growth and decay models, Population growth models, Effects of Immigration and Emigration on Population size, decrease of temperature, Diffusion, Change of price of a commodity, Logistic law of population growth, A simple compartment models, Diffusion of glucose or a Medicine in the blood stream.

UNIT II
Mathematical modeling of epidemics, A simple epidemics model, A susceptible-infected-susceptible (SIS) model, SIS model with constant number of carriers, Simple epidemic model with carriers, Model with removal, Model with removal and immigration, Mathematical modeling in economics, Domar macro model, Domar first debt model, Domar second debt model, Samuelson investment model, Stability of market equilibrium, Mathematical modeling in medicine, A model for diabetes mellitus, Arms race and battles: Richardson model for arms race, Lamechester combat model.

UNIT III
Mathematical modeling through partial differential equations: Mass-balance Equations, Momentum-
balance Equations, Variational principles, Probability generating function, Modeling for traffic on a highway.

UNIT IV

Stochastic models of population growth, Need for stochastic models, Linear birth-death-immigration-
emigration processes, Linear birth-death process, Linear birth-death-immigration process, Linear birth-death-emigration process, Non-linear birth-death process.

TEXT BOOKS

1. Burghes D.N. and Wood A.D., *Mathematical Models in the Social, Management and Life Sciences,* John Wiley and Sons,1980
2. Andrews J.G. and Mclone R.R, *Mathematical Modeling,* Butterworths (Pub.) Inc., 1976

REFERENCE BOOKS

1. Kapur J.N., *Mathematical Modeling,* New Age International Limited, 2015
2. Kapur J.N., *Mathematical Models in Biology and Medicine,* Affiliated East-West Press (P)
   Ltd., 1985

M.Sc. MATHEMATICS (AUDIT COURSE)

CODE: AC21-201B

SUBJECT NAME: ELEMENTARY NUMBER THEORY

NO. OF CREDITS: 2

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
2	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: understand division Algorithm, GCD and LCM, Fundamental Theorem of Arithmetic.
CO2: linear congruences and their properties, Chinese Remainder Theorem.
CO3: derive and apply Fermat's and Wilson's theorems.
CO4: understand greatest integer function, Euler's phi-function and its properties.

UNIT – I

Divisibility, Division algorithm, G.C.D. (Greatest Common Divisors), L.C.M (Least Common Multiple), Prime numbers, Euclidean algorithm, Fundamental theorem of Arithmetic.

UNIT – II

Congruences and basic properties, Linear Diophantine equation, Chinese remainder theorem.

UNIT – III

Fermat's little theorem and applications, Wilson's theorem and applications, Number theoretic functions, sum and number of divisors, perfect numbers.

UNIT – IV

The greatest integer function and its properties, Euler's Phi‑function and its properties.

TEXT BOOKS

1. Burton D. M., *Elementary Number Theory,* 6th edition, Tata McGraw Hill Edition, Indian reprint, 2007.
2. Apostol T. M., *Introduction to Analytic Number Theory,* Narosa Publication House, New Delhi, 2013.

REFERENCE BOOKS

1. Robbins N.**,** *Beginning Number Theory,* 2nd edition, Jones & Bartlett Learning, 2017.
2. Jones G. A. and Jones J.M., *Elementary Number Theory,* Springer, 1998.

M.Sc. MATHEMATICS (Open Elective Course)
CODE: OMATH21-203A
SUBJECT NAME: GRAPH THEORY
NO. OF CREDITS: 3

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75

3 0 0 TOTAL : 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:
After the completion of this course, the learner will be able to:

CO1: Understand about graph subgraphs and matrix representation of graphs.
CO2: Understand Hamiltonian circuit, Eulerian path and directed graphs.
CO3: Understand colouring of graphs and trees.
CO4: Understand minimal spanning trees and tree searching.

UNIT I
Definition of Graphs, special graphs, subgraphs, isomorphism of graphs, walk, Paths, Circuits, Euler's formula for connected planar graph, Complete and complete bipartite graphs, matrix representation of graphs.

UNIT II
Eulerian path and circuits, Hamiltonian circuits, planar graphs, Euler's theorem on existence of Eulerian paths and circuits, directed graphs, weighted undirected graphs.

UNIT III
Coloring of graphs, trees, isomorphism of trees, indegree and outdegree of a vertex, spanning tree of a graph.

UNIT IV
Shortest path problems, Minimal spanning tree, Prim algorithm, Kruskal's algorithm, tree searching.

TEXT BOOKS

1. Babu Ram, *Discrete Mathematics*, Pearson Publications.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* 3rd Edition, Pearson Education Pte. Ltd., Indian Reprint 2018.

REFERENCE BOOKS

1. C.L. Liu*, Elements of Discrete Mathematics*, McGraw-Hill. 1985.
2. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 2002.

M.Sc. MATHEMATICS (Open Elective Course)
CODE: OMATH21-204A
SUBJECT NAME: BASICS OF STATISTICS

NO. OF CREDITS: 3

			SESSIONAL	: 25
L	T	P	FINAL EXAM	: 75
3	0	0	TOTAL	: 100

NOTE: Question paper has two parts. Part-1 has 10 questions each of equal marks. It covers the entire syllabus. Attempt any four questions out of six from Part-2.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: Formulate and analyze mathematical and statistical problems based on central tendency.

CO2: Use statistical methods to solve well-defined problems based on correlation and regression.

CO3: Read, understand and construct correct data, use the data-bases to locate information on mathematical problems.

CO4: Learn about concept of probability and theorems based on it.

UNIT – I

Measurement of Central Tendency and variation: Mean, Median and Mode, Mean Deviation, Standard Deviation, Variance, Coefficient of Variation.

UNIT-II

Correlation Analysis: meaning, significance, types and methods, Regression Analysis: equations and lines, Difference between correlation and regression.

UNIT – III

Probability: Definition and various approaches of probability, addition theorem, multiplication theorem and Conditional probability, Independent events, Mutual and pairwise independence of events.

UNIT - IV

Baye's theorem and its applications, Discrete Distributions: Bernoulli distribution, Binomial Distribution.

TEXT BOOKS

1. Gupta S.C. and Kapoor V.K., Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi.
2. Speigel, M., Probability and Statistics, Schaum Outline Series

REFERENCE BOOKS

1. Baisnab A. and Jas M., Element of Probability and statistics, Tata McGraw Hill.
2. Gupta S.P., Statistical Methods S. Chand & Co.

M.Sc. MATHEMATICS (Value Added Course)

CODE: VAC 01

SUBJECT NAME: HUMAN VALUES AND PROFESSIONAL ETHICS

NOTE: The value-added course is compulsory for students. It may be taught **through digital aided learning / class room teaching.** The total course duration is 35 hours. Minimum 75% attendance is compulsory for students and its evaluation will be done by concerned Dept. through Viva-Voce examination.

COURSE OUTCOMES:

After the completion of this course, the learner will be able to:

CO1: apply ethics in society.

CO2: discuss the ethical issues related to science and engineering and realize the responsibilities and rights in the society.

UNIT I: HUMAN VALUES

Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self-confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.

UNIT II: ETHICS

Senses of Ethics – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy –Consensus and Controversy – Models of professional roles - Theories about right action – Self-interest – Customs and Religion.

UNIT III: PROFESSIONALS AS SOCIAL EXPERIMENTATION

Social Experimentation – Professionals as responsible Experimenters – Codes of Ethics – A Balanced Outlook on Law.

UNIT IV: SAFETY, RESPONSIBILITIES AND RIGHTS

Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk - Respect for Authority – Collective Bargaining – Confidentiality –Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights

(IPR) Gender inequality, causes and consequences. Discrimination, Social understandings, Women and Men in the Organization, Consequences of sexual harassment.

UNIT V: GLOBAL ISSUES

Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development- Professionals as Managers – Consulting Engineers – Professionals as Expert Witnesses and Advisors Moral Leadership – Code of Conduct – Corporate Social Responsibility.

TEXT BOOKS

1. Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Tata McGraw Hill, New Delhi, 2003.
2. 2. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004.

REFERENCE BOOKS

1. Charles B. Fleddermann, "Engineering Ethics", Pearson Prentice Hall, New Jersey, 2004.
2. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, "Engineering Ethics – Concepts and Cases", Cengage Learning, 2009.
3. John R Boatright, "Ethics and the Conduct of Business", Pearson Education, New Delhi, 2003.
4. Edmund G Seebauer and Robert L Barry, "Fundametals of Ethics for Scientists and Engineers", Oxford University Press, Oxford, 2001.
5. Laura P. Hartman and Joe Desjardins, "Business Ethics: Decision Making for Personal Integrity and Social Responsibility" Mc Graw Hill education, India Pvt. Ltd.,New Delhi 2013.

WEB SOURCES

1. www.onlineethics.org
2. www.globalethics.org
3. www.ethics.org