GOVERNMENT ARTS COLLEGE (AUTONOMOUS)

COIMBATORE-641 018

Learning outcomes-based Curriculum Framework (LOCF) for

M.Sc. MATHEMATICS

(Effective from Academic year 2021-2022 Onwards)

POSTGRADUATE AND RESEARCH

DEPARTMENT OF MATHEMATICS

MAY-2021

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0 PREAMBLE

Over the past decades the higher education system of our country has undergone substantial structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. Such changes have gained momentum with the introduction of Choice Based Credit System (CBCS) which further expects learning outcome-based curriculum in order to maximize the benefits of the newly designed curriculum. The learning outcome-based curriculum will definitely help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. It is pertinent to mention here that the purpose of education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this.

Tamil Nadu State Council for Higher Education (TANSCHE) has formed the State Integrated Boards of Studies, which, with great diligence and expertise has devised the mandatory areas that have to be covered for three-year under graduation and two-year post graduation courses to realize the facilitation of the mobility of faculty and students from one university to another and to easily solve the problem of equivalence among courses. Great care has been taken so that these areas would take 75% of the course content and the remaining 25% can be decided by the individual institutions. The areas that must be covered by the student that are mandatory for earning the degree to have due value has been worked out so that the student will gain enough depth of knowledge in the subject concerned. 25% percent of the syllabus should be designed by the institutions, and the areas covered under this also must have a weightage of 25%. This gives the autonomous institution seamless liberty on every Board of Studies (BOS) to innovate and experiment, and more importantly, it is here that the institution devises appropriate strategies by which (i) to make creative and critical applications of what has been learnt in the mandatory components, and (ii) to meaningfully connect the learners to the career demands and expectations. It is essential that the theoretical subject knowledge of the students must be translated into practical hands-on experience.

The LOCF (Learning Outcomes based Curriculum Framework) committee constituted by University Grants Commission (UGC) is pleased to submit its report concerning the syllabi for M.Sc. Mathematics as a subject. The committee discussed the framework of syllabi in its meetings and suggests the implementation of these syllabi in the Departments of Mathematics in Government Arts College (Autonomous), Coimbatore based on following facts:

- The learning outcomes of each paper are designed so that these may help learners to understand the main objectives of studying the course.

- This will enable learners to select elective papers depending on the individual inclinations and contemporary requirements.

- The objectives of LOCF are to mentally prepare the students to learn Mathematics leading to post graduate degree in Mathematics.

- These syllabi in Mathematics under CBCS are recommended keeping in view of the wide applications of Mathematics in science, engineering, social science, business and a host of other areas.

- The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and health care sectors.

- The LOCF committee in Mathematics has prepared this draft paying suitable attention to objectives and learning outcomes of the papers. These syllabi may be implemented with minor modifications with appropriate justifications keeping in view regional, national and international context and needs.

- The outcomes of each paper may be modified as per the local requirements.
- The text books mentioned in references are denotative/demonstrative. The divisions of each paper in units are specified to the context mentioned in courses. These units will help the learners to complete the study of concerned paper in certain periods and prepare them for examinations.

- The papers are organized considering the credit load in a particular semester. The core papers of general interest are suggested for semesters I to IV. The elective courses are proposed for the M.Sc. students having Mathematics as a subject.

- The mathematics is a vast subject with immense diversity. Hence it is very difficult for every student to learn each branch of mathematics, even though each paper has its unique importance. Under these circumstances, LOCF in Mathematics suggests a number of elective papers along with compulsory papers. A student can select elective papers as per his/her needs and interests.

- The committee expects that the papers may be taught using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB to strengthen the conceptual understanding and to widen up the horizon of students self-experience.

- The committee of the LOCF in Mathematics expects that the concerned department will encourage their faculty members to include necessary topics in addition to courses suggested by LOCF committee. It is hoped that the needs of all round development in the careers of learners/students will be fulfilled by the recommendations of LOCF in Mathematics.

LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK IN M.Sc. MATHEMATICS AS A SUBJECT

1. INTRODUCTION

One of the significant reforms in the post graduate education is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes its student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. Outcome based learning is the principal end of pedagogical transactions in higher education in today's world in the light of exponential change brought about in science and technology, especially in mathematics, and the prevalent utilitarian world view of the society. The learning outcomes are attained by students through skills acquired during a programme of study. Programme learning outcomes will include subject-specific skills and generic skills, including transferable global skills and competencies. It would also focus on knowledge and skills that prepare students for further study, employment, and citizenship. They help ensure comparability of learning levels and academic standards across colleges/universities and provide a broad picture of the level of competence of post graduates.

The quality education in a subject like mathematics is a very challenging task for Higher Education System in India. UGC has already taken an appropriate measure to define the minimum levels of learning for mathematics courses for post graduate and post-graduate levels. The quality of higher education in mathematics should be improved in such a manner that young minds are able to compete in this field globally in terms of their knowledge and skills in the globalised era of the date. Also, there is an urgent need of sustained initiatives to be taken by colleges/institutes/universities for outcome-oriented higher education in mathematics so that post graduates are enabled to

enhance the chances of employability. Presently, the goal of higher education in mathematics may be achieved using the following measures:

i. Curriculum reform based on a learning outcomes-based curriculum framework (LOCF).

ii. Improving learning environment and academic resources.

iii. Elevating the quality of teaching and research.

iv. Involving students in discussions, problem-solving and out of box thinking about various ideas of mathematics and their applicability, which may lead to empowerment and enhancement of the social welfare at large.

v. Encouraging the learners to make use of LOCF to learn mathematics through distance education.

vi. Motivating the learners to understand various concepts of mathematics keeping in view the regional context.

vii. Enabling learners to create research atmosphere in mathematical sciences in their colleges/institutes/universities.

viii. Teach courses of mathematics based on Choice Based Credit System (CBCS).

One of the benchmarks to measure the progress of a country is the advancement of the knowledge of mathematics. Hence, innovative measures should be taken to improve the quality of mathematical knowledge in our society. This is also because mathematics has wide ranging applications in engineering, technology and a host of other areas.

1.1 Course Structure – Types of Courses.

The following types of courses are offered under CBCS-LOCF:

1. **Core Courses (CC):** A core course is a compulsory course. A student of Post graduate in Mathematics has to take 16 such Mathematics courses over four semesters.

2. **Elective Courses (EC):** An elective course is a course that is to be chosen from a specified set of courses.

I. **Skill Enhancement Course.** A student has to take one such course as an individual project in Semester IV.

II. **Discipline Specific Electives (DSE):** These are elective courses that provide advanced post graduate training in specialized areas of Zoology. A set of 4, one each in all the four semesters of the post graduate programme.

2. LEARNING OUT COMES -BASED APPROACH TO CURRICULUM PLANNING

The Master's Degree in M.Sc. Mathematics as a subject is awarded to the students on the basis of knowledge, understanding, skills, attitudes, values and academic achievements sought to be acquired by learners at the end of these programmes. Hence, the learning outcomes of mathematics for the recourses are aimed at facilitating the learners to acquire these attributes, keeping in view of their preferences and aspirations for knowledge of mathematics.

The LOCF in mathematics has designed courses in the light of post graduate attributes, description of qualifications, courses and programme learning outcomes. The committee has tried to frame the syllabi of mathematics in such a way that it may lead to all round development and delivery of complete curriculum planning. Hence, it provides specific guidelines to the learners to acquire sufficient knowledge during this programme.

The objectives of LOCF (Mathematics) is to prepare the syllabi having standard level of study. It is also aimed at prescribing standard norms for teaching-learning process and examination pattern. Hence, the programme has been chalked out in such manner that there is scope of flexibility and innovation in

i. modifications of prescribed syllabi.
ii. teaching-learning methodology.
iii. assessment technique of students and knowledge levels.
iv. learning outcomes of courses.
v. inclusion of new elective courses subject to availability of experts in colleges/institutes/universities across the country.

2.1 Nature and extent of Master's Degree Programme

Mathematics is the study of quantity, structure, space and change. It has very broad scope in science, engineering and social sciences. The key areas of study in mathematics are:

1.Modern Algebra, 2. Real Analysis, 3. Complex Analysis, 4. Ordinary Differential Equations, 5. Advanced Numerical Analysis , 6. Topology, 7. Measure and Integration, 8. Operations Research 9. Object Oriented Programming in C++, 10. Partial Differential Equations, 11. Number Theory, 12. Mechanics, 13. Graph Theory, 14. Functional Analysis, 15. Mathematical Statistics, 16. Operator Theory, 17. Fluid Dynamics, 18. Fuzzy Logic and Fuzzy Sets, 19. Calculus of Variations and Integral Equations, 20. Matlab

Post graduate degree programs in mathematics cover topics which are already mentioned in details under various headings are given. The depth and breadth of study of individual topics depend on the nature and devotion of learners' in specific mathematics programmes.

As a part of effort to enhance employability of mathematics post graduates, the courses have been designed to include learning experiences, which offer them opportunities in various sectors of human activities. In this context, the experience of the project work in the areas of applications of mathematics.

2.2 Aims of Master's degree programme in Mathematics

The overall aims of M.Sc. Mathematics as a subject are to

- create deep interest in learning mathematics.
- develop broad and balanced knowledge and understanding of definitions, concepts, principles and theorems.
- familiarize the students with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences.
- enhance the ability of learners to apply the knowledge and skills acquired by them during the programme to solve specific

theoretical and applied problems in mathematics.

- Provide students/learners sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics.
- encourage the students to develop a range of generic skills helpful in employment, internships and social activities.

3. POST GRADUATE ATTRIBUTES INMATHEMATICS

The Post graduate attributes in mathematics are the summation of the expected course learning outcomes mentioned in the beginning of each course. Some of them are stated below.

- **Disciplinary knowledge:**

Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an post graduate programme of study.

- **Communications skills:**

i. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
ii. Abilitytousemathematicsasapreciselanguageofcommunicationinoth erbranches of human knowledge.
iii. Ability to communicate long standing unsolved problems in mathematics.
iv. Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization.
v. Abilitytoexplainthedevelopmentofmathematicsinthecivilizationalco ntextandits role as queen of all sciences.

- **Critical thinking and analytical reasoning:**

i. Ability to employ critical thinking in understanding the concepts in every area of mathematics.

ii. Ability to analyse the results and apply them in various problems appearing in different branches of mathematics.

- **Research-related skills:**

i. Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
ii. To know about the advances in various branches of mathematics.

- **Information/digital literacy:**

i. Capability to use appropriate softwares to solve system of equations and differential equations.
ii. Capability to understand and apply the programming concepts of C++ and Matlab to mathematical investigations and problem solving.

- **Self-directed learning:**

  Ability to work independently and do in-depth study of various notions of mathematics.

- **Moral and ethical awareness/reasoning:**

  Ability to identify unethical behavior such as fabrication, falsification or misrepresentation of data and adopting objective, un biased and truthful actions in all aspects.

- **Lifelong learning:**

  Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.

4. QUALIFICATION DESCRIPTORS FOR M.Sc. MATHEMATICS AS ASUBJECT

The qualification descriptor suggests the generic outcomes and attributes to be obtained while obtaining the degree of M.Sc. with Mathematics as a subject. The qualification descriptors indicate the academic standards on the basis of following factors:

i. Level of Knowledge

ii. Understanding

iii. Skills

iv. Competencies

v. Values

These parameters are expected to be attained and demonstrated by the learners after becoming post graduates in these programmes. The colleges consider the above mentioned parameters at the time of designing, approving, assessing and reviewing academic programmes containing common courses for M.Sc. Mathematics as a subject. The learning experiences and assessment procedures should be so designed that every post graduate with mathematics may achieve the programme learning outcomes with equal opportunity irrespective of the class, gender, community and regions. Each post graduate in mathematics should be able to:

i. demonstrate fundamental systematic knowledge of mathematics and its applications in engineering, science, technology and mathematical sciences. It should also enhance the subject specific knowledge and help in creating jobs in various sectors.
ii. demonstrate educational skills in areas of analysis, geometry,

algebra, mechanics, differential equations etc.

iii. Apply knowledge, understanding and skills to identify the difficult/unsolved problems in mathematics and to collect the required information in possible range of sources and try to analyse and evaluate these problems using appropriate methodologies.

iv. fulfil one's learning requirements in mathematics, drawing from a range of contemporary research works and their applications in diverse areas of mathematical sciences.

v. apply one's disciplinary knowledge and skills in mathematics in newer domains and uncharted areas.

vi. Identify challenging problems in mathematics and obtain well-defined solutions.

vii. Exhibit subject-specific transferable knowledge in mathematics relevant to job trends and employment opportunities.

5. PROGRAMME LEARNING OUTCOMES OF M.SC. MATHEMATICS AS A SUJECT

Master's degree in mathematics is the culmination of in-depth knowledge of Modern Algebra, Real Analysis, Complex Analysis, Ordinary Differential Equations, Advanced Numerical Analysis , Topology, Measure and Integration, Operations Research, Object Oriented Programming in C++, Partial Differential Equations, Number Theory, Mechanics, Graph Theory, Functional Analysis, Mathematical Statistics, Operator Theory, Fluid Dynamics, Fuzzy Logic and Fuzzy Sets, Calculus of Variations and Integral Equations, Matlab and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.

0. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.

1. Students undergoing this programme learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems. They also shareideasandinsightswhileseekingandbenefittingfromknowledgean dinsightofothers.
Thishelpsthemtolearnbehaveresponsiblyinarapidlychanginginterdep endentsociety.

2. Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describemathematicalideasfrommultipleperspectivesandexplainfund amentalconceptsof mathematics to non-mathematicians.

3. Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools.

4. This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

6. TEACHING-LEARNING METHODOLOGIES

The teaching-learning process should be aimed at systematic exposition of basic concepts so as to acquire knowledge of mathematics in a canonical manner. In this context, applications of mathematics and linkage with the theory constitute a vital aspect of the teaching-learning process. The course offers many modes of learning and assessment. Students have great freedom of choice of subjects which they can study. The various components of teaching learning process are summarized in the following heads.

1. **Lectures:** The most common method of imparting knowledge is through lectures. There are diverse modes of delivering lectures such as through

blackboard, power point presentation and other technology aided means. A judicious mix of these means is a key aspect of teaching-learning process.

2. Tutorials: Assimilating mathematical ideas, deepening understanding, and gaining mastery of new concepts all take time, commitment, and intelligent effort. To reinforce learning, to monitor progress, and to provide a regular pattern of study, tutorials are essential requirements. During these tutorials, difficulties faced by the students in understanding the lectures, are dealt with. Tutorials are also aimed at solving problems associated with the concepts discussed during the lectures.

3. **Practicals:** To give a geometrical visualisation and obtaining numerical solutions of mathematical problems, various Computer Algebra Systems (CAS) are used in practical sessions. These sessions provide vital insights into mathematical concepts and draw learner's attention towards limitations of numerical computations. During practical's, mathematical models arising in real life problems can also be simulated.

4. Options System: LOCF in mathematics provides great flexibility both in terms of variety of courses and range of references in each course. In fifth and sixth semesters students can opt for elective courses from a wide range of pure and applied courses, depending on their interests and requirements.

5. **Field based learning:** Students may enhance their knowledge through field based learning while understanding the practical importance of mathematics especially in industries.

6. **Prescribed textbooks:** A large number of books are included in the list of references of each course for enrichment and enhancement of knowledge.

7. **E-learning resources:** Learner may also access electronic resources and educational websites for better understanding and updating the concepts.

8. **Self-study materials:** Self-study material provided by the teachers/instructors is an integral part of learning mathematics. It helps in bridging the gaps in the classroom teaching. It also provides scope for teachers to give additional information beyond classroom learning.

9. **Open-ended projects:** Home assignments at regular intervals and project work involving applications of theory are necessary to assimilate basic concepts of mathematics. Hence, it is incumbent on the part of a learner to complete open-ended projects assigned by the teacher.

10. **Internships:** The teaching-learning process needs to be further supported by other activities devoted to subject-specific and interdisciplinary skills, summer and winter internships in mathematics. During these internships it is expected that a learner will interact with experts and write a report on a topic provided to the learner.

11. **Institute visits:** Institute visit by a learner is also a part of learning process. During such visits a learner has access to knowledge by attending academic activities such as seminars, colloquia, library consultation and discussion with faculty members. These activities provide guidance and direction for further study.

12. **Industrial visits:** Industrial visits offer an opportunity to observe real time applications of mathematical concepts. These visits also give an opportunity to realise the power of mathematical ideas and their translation in problem solving.

13. **Training programmes:** Training programmes such as Mathematics Training and Talent Search (MTTS) program, organised by various agencies/institutes like National Board for Higher Mathematics, also provide an opportunity to learn various dimensions of mathematics.

7. ASSESSMENT METHODS

A range of assessment methods which are appropriate to test the understanding of various concepts of mathematics will be used. Priority will be given to formative assessment. Various learning outcomes will be assessed using time-bound examinations, series of open and closed book tests with uniform distribution over time, problem solving, home assignments, individual and group project reports, seminar presentations, viva-voce examination, participation in mathematical quizzes/competitions at local, regional, national and international levels and participations in internship programs. For various courses in mathematics, the following assessment methods shall be adopted:

i. Announced/unannounced quizzes

ii. Scheduled/unscheduled tests

iii. Problem solving sessions aligned with classroom lectures

iv. Practical assignments

v. Regular chamber consultation with faculty members

vi. Periodic tests, mid semester examination and semester end comprehensive examination

vii. Seminar presentations

viii. Computer skill test and computer simulation of concepts learnt

ix. Awareness tests of historical development of mathematical ideas

x. Awareness tests of recent advances in mathematics

xi. Awareness tests of various national/international prizes in mathematics including

Fields Medal, Abel prize, Rolf Nevanlinna Prize, Srinivasa Ramanujan Medal etc. and the work of recipients of these prizes

xii. Awareness test of applications of mathematics in other branches of science, technology and other disciplines.

8. STRUCTURE OF M.Sc., MATHEMATICS

M.Sc., DEGREE COURSE
SCHEME OF EXAMINATIONS: CBCS PATTERN
(For the students admitted during the academic year 2021-2022 and onwards)

SUBJECT CODE	TITLE OF THE PAPER	Hours/week	Internal (CA) Marks	External Marks	Total Marks	Ext– Min.	Total Pass Mark	Credits
SEMESTER – I								
21MMA11C	**CORE - I :** MODERN ALGEBRA	6	**50**	**50**	**100**	**25**	**50**	5
21MMA12C	**CORE - II:** REAL ANALYSIS	6	**50**	**50**	**100**	**25**	**50**	5
21MMA13C	**CORE - III:** COMPLEX ANALYSIS	6	**50**	**50**	**100**	**25**	**50**	5
21MMA14C	**CORE - IV:** ORDINARY DIFFERENTIAL EQUATIONS	6	**50**	**50**	**100**	**25**	**50**	4
21MMA15E	**ELECTIVE – I:** ADVANCED NUMERICAL ANALYSIS.	6	**50**	**50**	**100**	**25**	**50**	3
SEMESTER - II								
21MMA21C	**CORE - V:** TOPOLOGY	6	**50**	**50**	**100**	**25**	**50**	5
21MMA22C	**CORE - VI:** MEASURE AND INTEGRATION	6	**50**	**50**	**100**	**25**	**50**	5
21MMA23C	**CORE - VII:** OPERATIONS RESEARCH	6	**50**	**50**	**100**	**25**	**50**	5
21MMA24C	**CORE - VIII:** PARTIAL DIFFERENTIAL EQUATIONS	6	**50**	**50**	**100**	**25**	**50**	4
21MMA25E	**ELECTIVE – II :** NUMBER THEORY	6	**50**	**50**	**100**	**25**	**50**	3

SUBJECT CODE	TITLE OF THE PAPER	Hours/week	Internal (CA) Marks	External Marks	Total Marks	Ext– Min.	Total Pass Mark	Credits
SEMESTER – III								
21MMA31C	**CORE – IX :** MECHANICS	6	**50**	**50**	**100**	**25**	**50**	5
21MMA32C	**CORE - X:** GRAPH THEORY	6	**50**	**50**	**100**	**25**	**50**	5
21MMA33C	**CORE – XI :** FUNCTIONAL ANALYSIS	6	**50**	**50**	**100**	**25**	**50**	5
21MMA34C	**CORE – XII :**MATHEMATICAL STATISTICS	6	**50**	**50**	**100**	**25**	**50**	4
21MMA35E	**ELECTIVE – III :** OBJECT ORIENTED PROGRAMMING WITH C++	6	**50**	**50**	**100**	**25**	**50**	3
SEMESTER – IV								
21MMA41C	**CORE - XIII:** OPERATOR THEORY	6	**50**	**50**	**100**	**25**	**50**	4
21MMA42C	**CORE - XIV:** FLUID DYNAMICS	5	**50**	**50**	**100**	**25**	**50**	4
21MMA43C	**CORE - XV:** FUZZY LOGIC AND FUZZY SETS	5	**50**	**50**	**100**	**25**	**50**	4
21MMA44C	**CORE – XVI :** CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS	5	**50**	**50**	**100**	**25**	**50**	4
21MMA45E	**ELECTIVE – IV :** MATLAB	5	**50**	**50**	**100**	**25**	**50**	3
21MMA 65P	**PROJECT & VIVA-VOCE**	4	**50**	**50**	**100**	**25**	**50**	5
	TOTAL MARKS & TOTAL CREDITS				**2100**			**90**

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	I	21MMA11C	MODERN ALGEBRA	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Identify the concept of Automorphism groups and Permutation groups.
2. Illustrate counting principle and Direct products.
3. Demonstrate particular Euclidean ring and Polynomial rings
4. Organize information on polynomial rings over rational field and polynomial rings over Commutative rings.
5. Summarize extension field and roots of polynomial.
6. Categorize elements of Galois theory and Finite fields.

UNIT: I

GROUP THEORY: Automorphisms - Cayley's theorem – Permutation Groups.
(Chapter 2 – Sections: 2.8 to 2.10)

UNIT: II

GROUP THEORY: Another counting principle – Sylow's theorems – Direct products.
(Chapter 2 – Sections: 2.11 to 2.13)

UNIT: III

RING THEORY: A particular Euclidean ring, Polynomial rings – Polynomial rings over the rational field – Polynomial rings over commutative rings.
(Chapter 3 – Sections: 3.8 to 3.11)

UNIT: IV

FIELDS: Extension fields – Roots of polynomials – More about roots.
(Chapter 5 – Sections: 5.1, 5.3 and 5.5)

UNIT: V

FIELDS, FINITE FIELDS: The Elements of Galois Theory – Finite fields.
(Chapter 5 – Section: 5.6; Chapter 7 – Section: 7.1)

PEDAGOGY STRATEGIES

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminar
- Quizes

REFERENCE:

TOPICS IN ALGEBRA – I.N. HERSTEIN, Second Edition, Vikas Publishing Company, New Delhi, Second Reprint, 2006.

FURTHER READING:

1. **A FIRST COURSE IN ABSTRACT ALGEBRA** – JOHN B.FRALEIGH, Narosa Publishing House, New Delhi.
2. **MODERN ALGEBRA** – SURJEET SINGH andQAZIZAMEERUDDIN, Vikas Publishing Company, New Delhi.
3. **BASIC ABSTRACT ALGEBRA** – P.B.BHATTACHARYA, S.K.JAINandS.R.NAIPAUL, Cambridge University Press, New York.

INTERNET RESOURCES:

1. http://www.math.niu.edu>aaol>frames-index
2. https://nrich.maths.org

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes(CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	1	**Disciplinary knowledge**	✓	✓				✓
	2	**Communication skills**	✓					
	3	**Critical thinking**			✓	✓		✓
	4	**Research related skills**	✓			✓	✓	
	5	**Analytical reasoning**	✓		✓			✓
	6	**Problem solving**		✓		✓	✓	
	7	**Team work**	✓		✓		✓	
	8	**Moral and ethical awareness**	✓		✓		✓	✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	I	21MMA12C	REAL ANALYSIS	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Evaluate integral of a function of a real variable in the sense of Riemann-Stieltjes integral and its properties.
2. Reduce Riemann stieltjes integral to a finite sum.
3. Test Absolute and Conditional convergence.
4. Test the convergence of Sequences and Series
5. Find the sum of Infinite series and value of Infinite Products.
6. Apply Jacobians in Implicit function theorem and Inverse function theorem.
7. Analyze and study Multivariable Differential Calculus.
8. Discuss the mean value theorem for Differentiable functions.

UNIT: I

THE RIEMANN-STIELTJES INTEGRAL: The definition of the Riemann-Stieltjes integral – Linear properties – Integration by Parts – Change of variable in a Riemann-Stieltjes integral – Reduction to a Riemann integral – Step functions as integrators – Reduction of a Riemann-Stieltjes integral to a finite sum – Euler's summation formula – Monotonically increasing integrators. Upper and lower integrals – Additive and linearity properties of upper and lower integrals – Riemann's condition – Comparison theorems – Integrators of bounded variation – Sufficient conditions for existence of Riemann-Stieltjes integrals – Necessary conditions for existence of Riemann-Stieltjes integrals – Mean-value theorems for Riemann-Stieltjes integrals.

(Chapter 7. Sections – 7.3 to 7.18)

UNIT: II

INFINITE SERIES AND INFINITE PRODUCTS: Convergent and divergent sequences of complex numbers – Limit superior and limit inferior of real-valued sequence – Monotonic sequences of real numbers – Infinite series – Inserting and removing parenthesis – Alternating series – Absolute and conditional convergence – Tests for convergence of series with positive terms – The geometric series – The integral test – The big oh and little oh notation – The ratio test and root test – Dirichlet's test and Abel's test – Rearrangement of series – Riemann's theorem on conditionally convergent series.

(Chapter 8 – Sections: 8.2 to 8.8, 8.10 to 8.15, 8.17 to 8.18)

UNIT: III

INFINITE SERIES AND INFINITE PRODUCTS (CONTINUED): Subseries – Double sequences- Double series – Rearrangement theorem for double series – A sufficient condition for equality of iterated series – Infinite products.

SEQUENCES OF FUNCTIONS: Pointwise convergence of sequences of functions - Examples of sequences of real-valued functions – Definition of uniform convergence, Uniform convergence and continuity – The Cauchy's condition for uniform convergence – Uniform convergence of infinite series of functions.

(Chapter 8 – Sections: 8.19 to 8.23, 8.26; Chapter 9 – Sections: 9.1 to 9.6)

UNIT: IV

SEQUENCES OF FUNCTIONS (CONTINUED): Uniform convergence and Riemann-Stieltjes integration – Nonuniformly convergent sequences that can be integrated term by term – Uniform convergence and differentiation – Sufficient conditions for uniform convergence of a series.

MULTIVARIABLE DIFFERENTIAL CALCULUS: The directional derivative – Directional derivatives and continuity – The total derivative – The total derivative expressed in terms of partial derivatives – The matrix of a linear function – The Jacobian matrix – The chain rule.

(Chapter 9 – Sections: 9.8 to 9.11 and Chapter 12 - Sections: 12.2 to 12.5, 12.7 to 12.9)

UNIT: V

MULTIVARIABLE DIFFERENTIAL CALCULUS (CONTINUED): The Mean-Value Theorem for differentiable functions – A sufficient condition for differentiability – A sufficient condition for equality of mixed partial derivatives – Taylor's formula for functions from R^n to R^1

IMPLICIT FUNCTIONS AND EXTREMUM PROBLEMS: Functions with nonzero Jacobian determinant – The inverse function theorem – The implicit function theorem.

(Chapter 12 – Sections: 12.11 to 12.14 and Chapter 13 – Sections: 13.2 to 13.4)

PEDAGOGY STRATEGIES

- Board and Chalk lecture
- Powerpoint slide presentations
- Seminar
- Assignments
- Online and Offline Class Practicals
- Quizes
- Group discussion

REFERENCES:

MATHEMATICAL ANALYSIS– TOM M.APOSTOL,Second Edition,Narosa Publishing House, 2002.

FURTHER READING:

REAL AND COMPLEX ANALYSIS – WALTER RUDIN, Tata McGraw Hill Publishing Company Limited.

INTERNET RESOURCES:

1. https://youtu.be/rvYVKusAeE8
2. https://youtu.be/i0j7c65Xw-Q
3. https://youtu.be/0M2jB8QhM0c
4. https://youtu.be/xPyy2uSzKjU

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)							
			1	2	3	4	5	6	7	8
Program Level Outcomes (PLO)	**1**	**Disciplinary knowledge**	✓	✓			✓			✓
	2	**Communication skills**	✓		✓			✓		
	3	**Critical thinking**		✓	✓		✓	✓	✓	
	4	**Research related skills**	✓				✓			
	5	**Analytical reasoning**	✓			✓	✓	✓		✓
	6	**Problem solving**	✓	✓	✓	✓	✓	✓	✓	✓
	7	**Team work**		✓		✓	✓			
	8	**Moral and ethical awareness**			✓		✓		✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	I	21MMA13C	COMPLEX ANALYSIS	6

COURSE LEVEL OUTCOMES:

On successful completion of the course, student will be able to:

1. Identify the limits and continuity for complex functions as well as consequence of continuity.
2. Discuss the concept and consequence of analyticity and the Cauchy- Rieman equation and of the results on harmonic and entire functions including fundamental theorem of Algebra.
3. Evaluate integrals along a path in the complex plane and understand the statement of Cauchy's theorem.
4. Explain about Taylor and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem
5. Illustrate the residues and evaluate complex integrals using the residue theorem.

UNIT: I

THE GENERAL FORM OF CAUCHY'S THEOREM: Chains and cycles – Simple connectivity – Homology – The general statement of Cauchy's theorem – Proof of Cauchy's theorem.

THE CALCULUS OF RESIDUES: The residue theorem – The argument principle – Evaluation of definite integrals.

(Chapter 4 – Sections: 4.1 to 4.5, 5.1 to 5.3)

UNIT: II

HARMONIC FUNCTIONS: Definition and basic properties – The mean value property – Poisson's formula.

POWER SERIES EXPANSIONS: Weierstrass's theorem – The Taylor series – Laurent series.

(Chapter 4 – Sections: 6.1 to 6.3 and Chapter 5 – Sections: 1.1 to 1.3)

UNIT: III

PARTIAL FRACTIONS AND FACTORIZATION: Partial fractions – Infinite products – Canonical products – The Gamma function.

ENTIRE FUNCTIONS: Jensen's formula

(Chapter 5 – Sections: 2.1 to 2.4 and 3.1)

UNIT: IV

THE RIEMANN ZETA FUNCTION: The product development – Extension of $\xi(s)$ to the whole plane – The functional equation – The zeros of the zeta function.

NORMAL FAMILIES: Equicontinuity – Normality and compactness – Arzela's theorem

(Chapter 5 – Sections: 4.1 to 4.4, 5.1 to 5.3)

UNIT: V

SIMPLY PERIODIC FUNCTIONS: Representation by exponentials – The Fourier development – Functions of finite order.

DOUBLY PERIODIC FUNCTIONS: The periodic module – Unimodular transformations – The canonical basis – General properties of elliptic functions.

(Chapter 7 – Sections: 1.1 to 1.3, 2.1 to 2.4)

PEDAGOGY STRATEGIES:

- Board and Chalk Lecture
- Powerpoint slide presentations.
- Assignments.
- Quizes.

REFERENCE:

COMPLEX ANALYSIS – LARS.V.AHLFORS, Third Edition, McGraw Hill International Edition, Fifth Reprint, 1983.

FURTHER READING:

THE ELEMENTS OF COMPLEX ANALYSIS – B.CHOUDHARY, Wiley Eastern Limited.

INTERNET RESOURCES:

1. http://people.match.gatech.edu
2. https://editorialdinosaurio.files.wordpress.com

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)				
			1	**2**	**3**	**4**	**5**
Program Level Outcomes (PLO)	1	**Disciplinary knowledge**	✓	✓	✓		
	2	**Communication skills**	✓			✓	✓
	3	**Critical Thinking**		✓	✓	✓	
	4	**Research related skills**		✓		✓	
	5	**Analytical reasoning**	✓	✓	✓		
	6	**Problem solving**				✓	✓
	7	**Team work**			✓	✓	✓
	8	**Moral and ethical awareness**	✓	✓			

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	I	21MMA14C	ORDINARY DIFFERENTIAL EQUATIONS	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Develop the linear Ordinary Differential Equations (ODE) and obtain its exact solutions.
2. Classify the mathematical problems using ODE and system of ODE and solve them using different mathematical approaches.
3. Compare the physical quantities in the obtained solutions with the original problems under reference.
4. Organize the general solutions using the initial and boundary conditions.
5. Categorize modern concepts and methodologies to solve large scale problems in ODE.
6. Explain the modern concept used in Mathematical Physics

UNIT: I

LINEAR EQUATIONS WITH CONSTANT COEFFICIENTS: Introduction – second order homogenous equation – Initial value problem – linear dependence and independence – A formula for the Wronskian.
(Chapter 2- Sections: 1 to 5)

UNIT: II

LINEAR EQUATIONS WITH CONSTANT COEFFICIENTS (CONTD): Non-homogeneous equation of order two –Homogeneous equations of order n – Initial value problems for n^{th} order equations –Equations with real constants-The non-homogeneous equation of order n-A special method for solving the non-homogenous equations.
(Chapter 2- Sections: 6 to 11)

UNIT: III

LINEAR EQUATIONS WITH VARIABLE COEFFICIENTS: Introduction-Initial value problem for homogeneous equation – solution of the homogeneous equation – The Wronskian and linear independence – Reduction of the order of homogeneous equation.
(Chapter 3- Sections: 1 to 5)

UNIT: IV

LINEAR EQUATIONS WITH REGULAR SINGULAR POINTS: The Legendre equations – Euler equation - second order equation with regular singular points an example and general case – solution and properties of Bessel's equation.
(Chapter 3 - Section:8 and chapter 4- Sections: 1 to 4 and 7 and 8)

UNIT: V

FIRST ORDER EQUATIONS – EXISTENCE AND UNIQUENESS: Existence and uniqueness of solution to first order equation – Equations with variable separated – Exact equation – Method of successive approximations –Lipschitz Condition – Convergence of the successive approximations.

(Chapter 5-Sections: 1 to 6)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminar
- Quizes
- Group Discussion

REFERENCE:

AN INTRODUCTION TO ORDINARY DIFFERENTIAL EQUATIONS-E. A. CODDINGTON, Prentice Hall of India, New Delhi, 1994.

FUTHER READING:

1. ESSENTIAL OF ORDINARY DIFFERENTIAL EQUATIONS – R.P. AGARWAL and RAMESH C.GUPTA, McGraw Hill, New York, 1991.
2. ORDINARY DIFFERENTIAL EQUATIONS- D.SOMASUNDARAM, Narosa publishing House, Chennai, 2002.
3. TEXT BOOK OF ORDINARY DIFFERENTIAL EQUATIONS – S.G. DEO, V. LAKSHMIKANTHAM AND V. RAGHAVENDRA, Second Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.

INTERNET RESOURCES:

1.https://nsufl.libguides.com/cnso-diffeq

2.https://www.khanacademy.org

3.https://mathworld.wolfram.com

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	1	Disciplinary knowledge		✓			✓	✓
	2	Communication skills	✓		✓			✓
	3	Critical thinking		✓	✓		✓	✓
	4	Research related skills	✓				✓	
	5	Analytical reasoning	✓			✓	✓	✓
	6	Problem solving	✓	✓	✓	✓	✓	✓
	7	Team work		✓		✓	✓	
	8	Moral and ethical awareness			✓		✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	**I**	**21MMA15E**	**ADVANCED NUMERICAL ANALYSIS**	**6**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1**.** Discuss the method of solving non- linear equations and Compute numerical solution of Algebraic and Transcendental equation.
2. Apply Interpolation concepts and Approximation of Functions and impart knowledge on modern techniques for constructing smooth curves using spline curves.
3. Illustrate the methods of finding numerical solutions to differential equations of various order.
4. Develop skills in framing more accurate integration formulas and give the details for using spline approximation to compute derivatives and integrals
5. Describe various methods for solving Boundary ValueProblems.
6. Develop knowledge to solve partial differential equation using Liebmann's method and Crank-Nicolson method.

UNIT: I

SOLVING NONLINEAR EQUATIONS: Interval Halving (Bisection) – Linear Interpolation Methods, Secant method, False position method – Newton's Methods – Muller's Method – Fixed-Point Iteration: x=g(x) Method – Multiple Roots – Nonlinear Systems.

(Chapter 1 – Sections: 1.1 to 1.7.)

UNIT: II

INTERPOLATION AND CURVE FITTING: Interpolating Polynomials – Divided Differences – Spline Curves – Bezier Curves and B-Splines Curves – Interpolating on a Surface – Least-Squares Approximations.

APPROXIMATION OF FUNCTIONS: Chebyshev Polynomials and Chebyshev Series-Rational Functions Approximations.

(Chapter 3: Sections: 3.1 to 3.6; Chapter 4 – Sections: 4.1 and 4.2)

UNIT: III

NUMERICAL DIFFERENTIATION AND INTEGRATION: Differentiation with a Computer – Numerical Integration, Derivatives from forward, backward, central and divided difference table – Richardson extrapolation – The Trapezoidal Rule, Romberg integration – Simpson's Rule – An Application of Numerical Integration –Adaptive Integration – Gaussian Quadrature – Multiple Integrals – Applications of Cubic Splines.

(Chapter 5 – Sections: 5.1 – 5.3 & 5.5 to 5.8)

UNIT: IV

NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS: The Taylor-Series Method – The Euler Method and its Modifications – Runge-Kutta Methods – Multistep Methods – Higher-order Equations and Systems – Stiff Equations – Boundary-Value Problems

(Chapter 6 – Sections: 6.1 to 6.7)

UNIT: V

NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS: Elliptic Equations – Iterative methods – Liebmann's method – Poission's equations.

Parabolic equations – Solving the heat equation - the Crank –Nicolson method.

Hyperbolic equations – Solving the vibrating string problem – the D' Alembert's solution – the wave equation in two dimensions.

(Chapter 8 – Sections: 8.1 – 8.3)

Note: The MATLAB programmes are omitted in all the units.

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Quizes

REFERENCE:

APPLIED NUMERICAL ANALYSIS – CURTIS F.GERALD and PATRICK O.WHEATLEY, Seventh Edition, Pearson Education Publisher, 2004.

FURTHER READING:

1. NUMERICAL METHODS FOR ENGINEERS AND SCIENTISTS – J.N.SHARMA, Second Edition, Narosa Publishers, 2007.
2. INTRODUCTORY METHODS OF NUMERICAL ANALYSIS – S.S SASTRY, Third Edition, Prentice Hall Publishing India Private Limited, New Delhi - 2003.

INTERNET RESOURCES:

https://learn.canvas.net>courses.

https://www.math.ust.hk>nu...pdf

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	1	Disciplinary knowledge				✓	✓	✓
	2	Communication skills		✓	✓	✓		
	3	Critical thinking	✓		✓		✓	✓
	4	Research related skills	✓	✓		✓		✓
	5	Analytical reasoning	✓		✓		✓	
	6	Problem solving		✓	✓			✓
	7	Team work	✓	✓			✓	
	8	Moral and ethical awareness			✓	✓		✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	**II**	**21MMA21C**	**TOPOLOGY**	**6**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Define a topological space, find different types of topologies and basis.
2. Distinguish continuous functions on topological spaces and the concept of metric topology and product topology.
3. Identify connected spaces.
4. Analyze compact spaces.
5. Prove countability axioms and separation axioms.

UNIT: I

TOPOLOGICAL SPACES: Topological spaces – Basis for a Topology – The order topology – The product topology on $X \times Y$ – The subspace topology – Closed sets and limit points.

(Chapter 2 – Sections: 12 to 17)

UNIT: II

CONTINUOUS FUNCTIONS: Continuous functions – The product topology – The metric topology and its continuation.

(Chapter 2 – Sections: 18 - 21)

UNIT: III

CONNECTEDNESS: Connected spaces – Connected subspaces of the real line – Components and local connectedness

(Chapter 3 – Sections: 23 - 25)

UNIT: IV

COMPACTNESS: Compact spaces – Compact subspaces of the real line and limit point compactness-Local compactness

(Chapter 3 – Sections: 26 - 29)

UNIT: V

COUNTABILITY AND SEPARATION AXIOMS, THE TYCHONOFF THEOREM: The countability axioms – The separation axioms – Normal spaces –The Urysohn lemma – The Urysohnmetrization theorem -The Tychonoff theorem.
(Chapter 4 – Sections: 30 to 34 and Chapter 5 – Section: 37)

PEDAGOGY STRATEGIES:

- Board and Chalk Lecture
- PowerPoint slide presentations
- Assignments
- Seminars
- Quizzes

REFERENCE:

TOPOLOGY – JAMES R. MUNKRES, Second Edition, Prentice Hall of India Private Limited, New Delhi, 2010.

FUTHER READING:

1. INTRODUCTION TO TOPOLOGY AND MODERN ANALYSIS - G.F.SIMMONS, McGraw Hill International Edition, Second Reprint, 2004.
2. INTRODUCTION TO GENERAL TOPOLOGY - K.D.JOSHI, New Age International Pvt Ltd,1983

INTERNET RESOURCES:

1. https://math.ucr.edu/~res/math205B-2021/solutions/gentop-solutions.pdf
2. https://dougsworldsite.files.wordpress.com/2017/08/munkres-topology-ch-3.pdf
3. https://dougsworldsite.files.wordpress.com/2017/08/munkres-topology-ch-2.pdf
4. https://www.mathcity.org/msc/notes/topology-handwritten-notes

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)				
			1	2	3	4	5
Program Level Outcomes (PLO)	1	Disciplinary knowledge	✓	✓	✓	✓	✓
	2	Communication skills					
	3	Critical thinking	✓	✓	✓	✓	✓
	4	Research related skills	✓	✓	✓	✓	✓
	5	Analytical reasoning	✓	✓	✓	✓	✓
	6	Problem solving	✓	✓	✓	✓	✓
	7	Team work	✓	✓		✓	
	8	Moral and ethical awareness		✓		✓	✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	II	21MMA22C	MEASURE AND INTEGRATION	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Discuss the basic ideas of measure theory which generalizes the concept of length, area, volume, summation and integration in general setup.
2. Describe the fundamental concept of Lebesgue outer measure and its properties.
3. Distinguish between Riemann and Lebesgue integration and the ramifications on convergent sequence of functions.
4. Analyze the four derivatives and evolve the relation between integration and differentiation.
5. Explain the L^p spaces of functions of a real variable and to establish several inequalities involving the norm $\|.\|$ in the L^p spaces.
6. Illustrates the concepts of completeness of normed linear space and establish the Littlewood's second principle.

UNIT: I

LEBESGUE MEASURE: Introduction–Outer Measure – Measurable sets and Lebesgue measure – Measurable functions – Littlewood's three principles.
(Chapter 3 – Sections: 1 to 3, 5, 6)

UNIT: II

THE LEBESGUE INTEGRAL: The Lebesgue integral of a bounded function over a set of finite measure – The integral of a non-negative function – The general Lebesgue integral – Convergence in measure.
(Chapter 4 – Sections: 2 to 5)

UNIT: III

DIFFERENTIATION AND INTEGRATION: Differentiation of monotonic functions – Functions of bounded variation – Differentiation of an integral – Absolute continuity.
(Chapter 5 – Sections: 1 to 4)

UNIT: IV

DIFFERENTIATION AND INTEGRATION: Convex Functions

THE CLASSICAL BANACH SPACES: The L^p spaces – The Minkowski and Holder inequalities.
(Chapter 5 – Section: 5 and Chapter 6 – Sections: 1, 2)

UNIT: V

THE CLASSICAL BANACH SPACES: Convergence and completeness – Approximation in the L^pspaces – Bounded linear functional on the L^p spaces.
(Chapter 6 – Sections: 3 to 5)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Quizes
- Seminor

REFERENCE:

REAL ANALYSIS – H.L.ROYDEN, Third Edition, Prentice Hall of India Private Limited, New Delhi, 2009.

FUTHER READING:

MEASURE THEORY AND INTEGRATION – G.DEBARRA, New Age International, 1996.

INTERNET RESOURCES:

https://nptel.ac.in/course/111/108/111108135/

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			COURSE LEVEL OUTCOMES (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	**1**	**Disciplinary knowledge**	✓	✓		✓	✓	
	2	**Communication skills**	✓		✓			✓
	3	**Critical thinking**		✓			✓	✓
	4	**Research related skills**			✓	✓	✓	
	5	**Analytical reasoning**	✓	✓		✓		
	6	**Problem solving**	✓	✓	✓		✓	
	7	**Team work**		✓		✓	✓	
	8	**Moral and ethical awareness**	✓		✓		✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	II	21MMA23C	OPERATIONS RESEARCH	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Identify the methods to solve advanced linear programming problems.
2. Discuss the concept of Decision Analysis and Simulation.
3. Appraise the Dynamic Programming and Game Theory Problems.
4. Explain the Non Linear Programming.
5. Illustrate the Non Linear Programming methods of finding the solution.
6. Describe various methods to solve both algebraic and transcendental equations.

UNIT: I

DUAL SIMPLEX METHOD, REVISED SIMPLEX METHOD: Product form of the inverse – Steps of the primal revised method.
POST OPTIMAL ANALYSIS: Changes affecting feasibility– Changes affecting optimality.
PARAMETRIC LINEAR PROGRAMMING: Parametric changes in c – Parametric changes in b.
(Chapter 4 - 4.4 Section: 4.4.1, 4.5.1, 4.5.2; Chapter 7 - 7.2 Sections: 7.2.1, 7.2.2; and Chapter 7 - 7.5 Sections: 7.5.1, 7.5.2)

UNIT: II
DECISION ANALYSIS: Decision making under certainty – Analytic hierarchy process. Decision making under risk – Decision tree based expected value criterion, Variations of the expected value criterion, Decision under uncertainty.
(Chapter 13 - Sections: 13.1 to 13.3)
SIMULATION: Monte-Carlo simulation – Types of simulation – Elements of discrete event simulation – Generation of random numbers – Mechanics of discrete simulation: Manual simulation of single server model.
(Chapter 16 - Sections: 16.1 to 16.4 and 16.5.1)
UNIT: III
DYNAMIC PROGRAMMING: Recursive nature of computations in DP – Forward and backward recursion – Selected DP applications.
GAME THEORY: Optimal solution of two person zero sum game – Solution of mixed strategy games.
(Chapter 10 - Sections: 10.1 to 10.3; Chapter 13 - Sections: 13.4)
UNIT: IV
NON LINEAR PROGRAMMING: Introduction – Formulating a nonlinear programming problem (NLPP) – General nonlinear programming problem – Constrained optimization with equality constraints - Constrained optimization with inequality constraints.
(Chapter 27 - Sections: 27.1 to 27.5)

UNIT: V

NON LINEAR PROGRAMMING METHODS: Introduction – Graphical solution – Kuhn-Tucker conditions with non-negative constraints – Quadratic programming – Wolfe's modified simplex method – Beale's method.
(Chapter 28 - Sections: 28.1 to 28.6)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Quizes

REFERENCES:

1. OPERATIONS RESEARCH-AN INTRODUCTION – HAMDY A. TAHA, Eighth Edition, Prentice Hall of India Private Limited, New Delhi.(For Units I, II and III)

2. OPERATIONS RESEARCH – KANTISWARUP, P.K. GUPTA AND MANMOHAN, Sultan Chand and Sons, Educational Publishers, New Delhi, Fourteenth Revised Edition.(For Units IV and V)

FURTHER READING:

PRINCIPLES AND APPLICATIONS OF OPERATIONS RESEARCH (From Maynard's Industrial Engineering Handbook, 5th Edition, pp. 11.27-11.44) - JAYANT RAJGOPAL

INTERNET RESOURCES:

1. htpp://www.introduction to Operations Research.com
2. htpp://www.Non Linear Programming .com

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	1	Disciplinary knowledge	✓	✓		✓	✓	
	2	Communication skills	✓		✓			✓
	3	Critical thinking		✓			✓	✓
	4	Research related skills			✓	✓	✓	
	5	Analytical reasoning	✓	✓		✓		
	6	Problem solving	✓	✓	✓		✓	
	7	Team work		✓		✓	✓	
	8	Moral and ethical awareness	✓		✓		✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	II	21MMA24C	PARTIAL DIFFERENTIAL EQUATIONS	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Associate various types of methods and their limitations to solve the partial differential Equations.
2. Appraise iinformation's received from the partial differential equations with real life situations.
3.Reconstruct the physical situations to formulate the mathematical models using PDE.
4.Apply the PDE using finite difference method and analyse the consistency, stability and convergence properties of numerical methods.
5.Develop the acquired knowledge to select the most appropriate method to solve the PDE.
6. Design partial differential equation models, which will be developed in the field heat and mass transport, wave phenomena such as sound and water waves.

UNIT: I

PARTIAL DIFFERENTIAL EQUATIONS OF FIRST ORDER: Formation and solution of PDE – Integral surfaces – Cauchy problem for first order equations – Orthogonal surfaces – First order non-linear equations – Characteristics – Compatible systems of first order equations – Charpit's method.
(Chapter 0 – Sections: 0.4 to 0.11)

UNIT: II

FUNDAMENTALS: Introduction – Classification of ssecond order PDE – Canonical forms – Adjoint operators – Riemann's method.
(Chapter 1- Sections: 1.1 to 1.5)

UNIT: III

ELLIPTIC DIFFERENTIAL EQUATIONS: Derivation of Laplace and Poisson equations – BVP – Separation of Variables – Dirichlet Problem and Newmann problem for a rectangle – Solution of Laplace equation in Cylindrical and Spherical coordinates – Examples.
(Chapter 2 – Sections: 2.1, 2.2, 2.5, 2.6, 2.7, 2.11, 2.12)

UNIT: IV

PARABOLIC DIFFERENTIAL EQUATIONS: Formation and solution of diffusion equation – Dirac Delta function – Separation of variables method – Solution of Diffusion equation in Cylindrical and Spherical coordinates – Examples.
(Chapter 3 – Sections: 3.1, 3.3 to 3.7)

UNIT: V

HYPERBOLIC DIFFERENTIAL EQUATIONS: Formation and solution of one-dimensional wave equation – Canonical reduction – IVP;D'Alembert's solution – IVP and BVP for two-dimensional wave equations – Periodic solution of one-dimensional wave equation in cylindrical and spherical polar coordinate systems – Uniqueness of the solution for the wave equation – Duhamel's Principle – Examples. (Chapter 4 – Sections: 4.1 to 4.4,4.7 to 4.9, 4.11, 4.12)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminar
- Quizes
- Group Discussion

REFERENCE:

INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS- K.SANKARA RAO,2^{nd} Edition, Prentice Hall of India, New Delhi, 2005.

FURTHER READING:

1. PARTIAL DIFFERENTIAL EQUATIONS - R. C. MCOWEN, 2^{nd} Edition, Pearson Eduction, New Delhi, 2005.
2. ELEMENTS OF PARTIAL DIFFERENTIAL EQUATIONS –I.N.SNEDDON, McGraw hill, New Delhi, 1983.
3. INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS AND BOUNDARY VALUE PROBLEMS - R. DENNEMEYER, McGraw hill, New Delhi, 1968.
4. ADVANCED DIFFERENTIAL EQUATIONS - M. D. RAISINGHANIA,S. Chand and Company Ltd., New Delhi, 2001.

INTERNET RESOURCES:

1. https://nsufl.libguides.com/cnso-diffeq

2. https://www.khanacademy.org

3. https://mathworld.wolfram.com

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcome (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	1	Disciplinary knowledge	✓	✓		✓	✓	
	2	Communication skills	✓		✓			✓
	3	Critical thinking		✓			✓	✓
	4	Research related skills			✓	✓	✓	
	5	Analytical reasoning	✓			✓		✓
	6	Problem solving	✓	✓			✓	
	7	Team work		✓		✓	✓	✓
	8	Moral and ethical awareness	✓		✓		✓	✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	II	21MMA25E	NUMBER THEORY	6

COURSE LEARNING OUTCOMES:

On the successful completion of the course, student will be able to:

1. Explain some concepts of Number Theory, a primary area of Mathematics, using examples.
2. Demonstrate the knowledge of concepts in divisibility and Primes.
3. Learn methods and technique in modulo n and use it to solve linear congruence.
4. Describe power residue and multiplicative groups.
5. Discuss the Quadratic residues and Jacobi symbol.
6. Apply greatest integer function and recurrence function.

UNIT: I

DIVISIBILITY: Introduction – Divisibility – Primes.
(Chapter I - Sections: 1.1 to 1.3)

UNIT: II

CONGRUENCES: Congruences – Solutions of congruences – The Chinese Remainder theorem – Prime power moduli - Prime modulus.
(Chapter II - Sections: 2.1 to 2.3, 2.6, 2.7)

UNIT: III

PRIMITIVE ROOTS AND POWER RESIDUES: Primitive roots and power Residues – Congruences of Degree two, Prime Modulus - Number theory from an algebraic view point – Groups, Rings, and Fields.
(Chapter II - Sections: 2.8 to 2.11)

UNIT: IV

QUADRATIC RECIPROCITY AND QUADRATIC FORMS: Quadratic residues - Quadratic reciprocity – The Jacobi symbol – Binary Quadratic forms
(Chapter III – Sections: 3.1 to 3.4)

UNIT: V

SOME FUNCTIONS OF NUMBER THEORY: Greatest integer function - Arithmetic functions – The Mobius inversion formula – Recurrence functions – Combinatorial Number Theory – Some Diophantine Equations – The equation ax+by=c.
(Chapter IV - Sections: 4.1 to 4.5; Chapter V - Section: 5.1)

PEDAGOGY STRATEGIES:

- Board and Chalk Lecture
- Seminar
- Assignments
- Online and offline Quizzes
- Group Presentation
- Discussion

REFERENCE:

AN INTRODUCTION TO THEORY OF NUMBERS– IVAN NIVEN AND HERBERT. S ZUCHERMAN, Third Edition, Wiley Eastern Limited, New Delhi, 1972.

FUTHER READING:

1. INTRODUCTION TO ANALYTIC NUMBER THEORY – TOM M.APOSTOL, Springer Verlag, 1976.

2. ELEMENTARY NUMBER THEORY AND ITS APPLICATIONS – KENNETH AND ROSAN, Addison Wesley Publishing Company, 1968.

3. Number Theory – George E Andrews, Hindustan Publishing, Dew Delhi, 1989.

4. An Introduction to the Theory of Numbers, 6th edition, by G.H. Hardy and E.M. Wright.

5. Algebraic Number Theory and Fermat's Last Theorem, 4th edition by Ian Stewart, David Tall.

6. A Classical Introduction to Modern Number Theory by Ireland, K., Rosen, M, 1990.

INTERNET RESOURSES:

1. An Introductory course in Elementary Number Theory, https://resources.saylor.org
2. Number Theory, https://www.maths.edu.ac.uk

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES:

Progrgramme Level Outcomes (PLO)			Course Level Outcomes (CLO)					
			1	2	3	4	5	6
	1	Disciplinary Knowledge	✓	✓		✓		
	2	Communication Skills	✓	✓				
	3	Critical Thinking		✓		✓		
	4	Research Related Skills			✓		✓	
	5	Analytical Reasoning						✓
	6	Problem Solving			✓			
	7	Team Work				✓	✓	
	8	Moral and Ethical Awareness			✓		✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	III	21MMA31C	MECHANICS	6

EXPECTED COURSE OUTCOMES:

On the successful completion of the course, student will be able to:

1. Understand the basic concepts of the mechanical system, generalized coordinates, work, energy and momentum.
2. Solve and analyse the Lagrange's equations and integrals of motion with examples.
3. Explore the Hamilton's Principle and other variational principles and gain ability to analyse those principles to the problems arising in practical situations
4. Derive the Hamilton's Principal function and Hamilton Jacobi equation
5. Analyse how the Relativistic kinematics and Relativistic dynamics differ from Newton Law's of motions.

UNIT: I
INTRODUCTORY CONCEPTS: The mechanical system – Generalized co-ordinates – Constraints – Virtual work – Energy and momentum.
(Chapter 1 - Sections: 1.1 to 1.5)

UNIT: II
LAGRANGE'S EQUATIONS: Derivation of Lagrange's equations – Examples – Integrals of the motion – Small oscillations.
(Chapter 2 - Sections: 2 .1 to 2 .4)

UNIT: III
HAMILTON'S EQUATION: Hamilton's principle – Hamilton's equations – Other variational principles.
(Chapter 4 - Sections: 4.1 - 4.3)

UNIT: IV
HAMILTON-JACOBI THEORY: Hamilton's principle function – The Hamilton-Jacobi equation –Separability.
(Chapter 5 - Sections: 5.1 to 5.3)

UNIT: V
INTRODUCTION TO RELATIVITY: Introduction – Relativistic kinematics – Relativistic dynamics.
(Chapter 7 - Sections: 7.1 to 7.3)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Assignments
- Quizes
- Seminars
- Group discussions

REFERENCE:

CLASSICAL DYNAMICS– DONALD T. GREENWOOD, Prentice Hall of India Private Limited, New Delhi, 1985.

FUTHER READING:

1. CLASSICAL MECHANICS– HERBERT GOLDSTEIN, Second Edition, Narosa Publishing House,1990.

2. THEORETICAL MECHANICS– MURRAY R. SPIEGEL, Tata McGraw Hill Education Private Limited, New Delhi, 2006.

INTERNET RESOURCES

- http://math.ucr.edu/home/baez/classical/texfiles/2005/book/classical.pdf.
- https://nptel.ac.in/courses/115/103/115103115/
- https://www.youtube.com/watch?v=G6OX1NpToaw

COURSELEVELMAPPINGOFPROGRAMLEVELOUTCOMES.

			Course Level Outcomes (CLO)				
			1	2	3	4	5
Programme Level Outcomes (PLO)	1	Disciplinary Knowledge	✓		✓		
	2	Communication skills	✓		✓	✓	
	3	Critical thinking		✓	✓	✓	✓
	4	Research related skills	✓	✓		✓	✓
	5	Analytical reasoning		✓	✓	✓	✓
	6	Problem solving	✓	✓	✓	✓	
	7	Team work			✓		✓
	8	Moral and ethical awareness	✓		✓		✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	III	21MMA32C	GRAPH THEORY	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. To enable the students to learn the basic concepts of Graphs, sub-graphs, matrix representation of graphs, trees, Colouring, Enumeration of graphs, Cover and Matching in graphs, Connectivity in graphs.
2. Identify the properties of different types of graphs and their applications.
3. Demonstrate knowledge of basic concepts in graph theory.
4. Summarize Variants in planar graphs
5. Develop the concepts of labelling and domination of graphs.
6.Graph principles and concepts of graph theory in practical situations.

UNIT: I

FUNDAMENTAL CONCEPTS: What is a graph - Paths, cycles and trails - Vertex degrees and counting

(Chapter 1- Sections: 1.1 to 1.3)

UNIT: II

TREES AND DISTANCE: Basic properties – Spanning trees and enumeration

(Chapter 2 - Sections: 2.1 and 2.2)

UNIT: III

MATCHINGS AND FACTORS: Matchings and covers - Matchings in general graphs

CONNECTIVITY AND PATHS: Cuts and connectivity - K-connected graphs.

(Chapter 3 - Sections: 3.1, 3.3; Chapter 4 - Sections: 4.1, 4.2)

UNIT: IV

COLORING OF GRAPHS: Vertex colorings and upper bounds - Structure of K-Chromatic graphs.

(Chapter 5 - Sections: 5.1 and 5.2)

UNIT: V

PLANAR GRAPHS: Embedding and Euler's formula.

EDGES AND CYCLES: Line graphs and edge coloring - Hamiltonian cycles.

(Chapter 6 - Section: 6.1; Chapter 7 - Sections: 7.1 and 7.2)

PEDAGOGYSTRATEGIES:

- Board and Chalk lecture
- Power points presentations
- Assignments
- Quizes

REFERENCE:

INTRODUCTION TO GRAPH THEORY – DOUGLAS B. WEST, Second Edition, PHI Learning Private Limited, New Delhi, 2009.

FURTHER READING:

1. GRAPH THEORY – NARSINGH DEO, Prentice Hall of India Private Limited, New Delhi, 1987
2. GRAPH THEORY - FRANK HARARY, Narosa Publishing House, New Delhi.

INTERNET RESOURCES:

1. http://www.math.uiuc.edu/~west/igt
2. https://youtu.be/PJvwRH2gVuM
3. https://youtu.be/aXaVIxvweHA
4. https://youtu.be/X4zqi0rf9OU
5. www.phindia.com

COURSELEVELMAPPINGOFPROGRAMLEVELOUTCOMES.

			Course Level Outcomes (CLO)				
			1	2	3	4	5
Programme Level Outcomes (PLO)	1	Disciplinary Knowledge	✓		✓		
	2	Communication skills	✓		✓	✓	
	3	Critical thinking		✓	✓	✓	✓
	4	Research related skills	✓	✓		✓	✓
	5	Analytical reasoning		✓	✓	✓	✓
	6	Problem solving	✓	✓	✓	✓	
	7	Team work			✓		✓
	8	Moral and ethical awareness	✓		✓		✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	III	21MMA32C	FUNCTIONAL ANALYSIS	6

EXPECTED COURSE OUTCOMES:

On the successful completion of the course, student will be able to:

1**.** Explain the concepts of functional analysis. Define the notion of a norm and use the basic theory of normed linear spaces and operators acting on these spaces to solve simple problems
2. Extend a linear functional under suitable conditions applying open mapping theorem.
3.Introduce the concepts of Hilbert spaces and Banach spaces, orthogonal complements, orthonormal sets and conjugate space.
4.Recognizethe concepts of linear operators, self adjoint, unitary operators and isometric isomorphism on Hilbert spaces.
5. Compute the spectrum of operators and classify the set into subclasses, show the spectrum to be nonempty, give expansion of resolvent operators.

UNIT: I

BANACH SPACES: The definition and some examples – Continuous linear transformations – The Hahn Banach theorem.
(Chapter 9 - Sections: 46 to 48)

UNIT: II

The natural imbedding of N in N^{**} – The open mapping theorem – The conjugate of an operator.
(Chapter 9 - Sections: 49 to 51)

UNIT: III

HILBERT SPACES: The definition and some simple properties – Orthogonal complements – Orthonormal sets – The conjugate space H^{*}.
(Chapter 10 - Sections: 52 to 55)

UNIT: IV

The adjoint of an operator – Self adjoint operators – Normal unitary operators – Projections.
(Chapter 10 - Sections: 56 to 59)

UNIT: V

FINITE DIMENSIONAL SPECTRAL THEORY: Matrices – Determinants and the spectrum of an operator – The spectral theorem.

GENERAL PRELIMINARIES ON BANACH ALGEBRAS: The definition and some examples – Regular and Singular elements.
(Chapter 11 - Sections: 60 to 62; Chapter 12 – Sections: 64 to 65)

PEDAGOGYSTRATEGIES:

- Board and Chalk ecture
- Power point slide presentations
- Assignments
- Quizes

REFERENCE:

INTRODUCTION TO TOPOLOGY AND MODERN ANALYSIS – G.F.SIMMONS, McGraw Hill Education(India) Pvt Ltd, New Delhi, Edition 2004.

FURTHER READING:

1. **A FIRST COURSE IN FUNCTIONAL ANALYSIS** – C.GOFFMAN AND G.PEDRICK, Prentice Hall of India, New Delhi, 1987.
2. **INTRODUCTION TO FUNCTIONAL ANALYSIS**– A.E.TAYLOR, John Wiley and Sons, New York, 1988.

INTERNET RESOURCES:

1. https://nptel.ac.in/courses/111/105/111105037/
2. https://ocw.mit.edu/courses/mathematics/18-102-introduction -to-functional-analysis-spring-2009/lecture-notes

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

			Course Level Outcomes (CLO)					
			1	2	3	4	5	6
Programme Level Outcomes (PLO)	1	**Disipilinary Knowledge**		✓		✓		✓
	2	**Communication Skills**		✓			✓	
	3	**Critical thinking**	✓		✓			
	4	**Research related skills**		✓	✓			✓
	5	**Analytical reasoning**	✓			✓		✓
	6	**Problem solving**		✓		✓	✓	
	7	**Team work**	✓		✓			✓
	8	**Moral and ethical Awarness**	✓	✓			✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	III	21MMA34C	MATHEMATICAL STATISTICS	6

COURSE LEARNING OUTCOMES:

On the successful completion of the course, student will be able to:

1. Identify the concepts of conditional probability, Baye's theorem, understanding the concept of random variables, probability distribution and distribution functions.
2. Understand the concept and derivation of of various order moments and to know about the two types of regression
3. Describe the different types of discrete and continuous distributions and their applications in practice.
4. Illustrate the importance of law of large numbers different types of Limit theorems by various mathematicians and their significance.
5. Explain the concept of sample, statistic and to study the sampling distributions of t, chi- square, F and to study the applications of parametric tests
6. Analyse the practical data with the sampling distributions.

UNIT: I

RANDOM EVENTS: The system of axioms of theory of probability – Conditional Probability – Baye's theorem – Independent events.

RANDOM VARIABLES: The concept of a random variable – The distribution function - Random Variables of the discrete type and the continuous type – Functions of random variables – Multidimensional random variables – Marginal distributions – Conditional distributions – Independent random variables.

(Chapter 1 -except Section: 1.4,Chapter 2 -Sections: 2.1 to 2.8)

UNIT: II

PARAMETERS OF THE DISTRIBUTION OF A RANDOM VARIABLE: Expected values – Moments – The Chebychev inequality – Absolute moments –Order parameters- Moments of random vectors- Regression of first type- Regression of Second type.

(Chapter 3 -Sections: 3.1 to 3.8)

UNIT: III

CHARACTERISTIC FUNCTIONS: Properties of characteristic functions – The characteristic functions and moments – Semi invariants - The characteristic function of the sum of independent random variables – Determinations of the distribution function by the characteristic function, Probability generating functions.

SOME PROBABILITY DISTRIBUTIONS: One point and two point distributions – The Bernoulli scheme – The binomial distribution – The Poisson scheme – The generalized binomial distribution – The Poisson distribution – The uniform, Normal, Gamma, Beta, Cauchy and Laplace distributions.

(Chapter 4 - Sections: 4.1 to 4.5 and 4.7; Chapter 5 - Sections: 5.1 to 5.10 except 5.4)

UNIT: IV

LIMIT THEOREMS: Stochastic convergence – Bernoulli's law of large numbers – The Levy-Cramer theorem- De Moivre-Laplace theorem – The Lindeberg-Levy theorem – The Lapunov theorem.
(Chapter 6 - Sections: 6.1 to 6.9 except 6.5)

UNIT: V

SAMPLE MOMENTS AND THEIR FUNCTIONS : The notion of a sample – Notion of a statistic – Distribution of arithmetic mean of independent normally distributed random variables – The chi-square distribution – Distribution of the statistic ($\bar{X}$,s) – Student's t-distribution – Fisher's Z-distribution

SIGNIFICANCE TEST: The concept of a statistical test – Parametric tests for small samples - Parametric test for large samples – The chi-square test.
(Chapter 9 -Sections: 9.1 to 9.7; Chapter 12 - Sections: 12.1 to 12.4)

PEDAGOGYSTRATEGIES:

- Board and Chalk lecture
- Power point slide presentations
- Assignments
- Quizes

REFERENCE:

PROBABILITY THEORY AND MATHEMATICAL STATISTICS – MAREK FISZ, ThirdEdition, John Wiley and Sons, 1963.

FUTHER READING:

1. INTRODUCTION TO MATHEMATICAL STATISTICS, R.V. Hogg and A.T. Craig, Fourth edition, Macmillan publishing Company, Newyork,1978.
2. MATHEMATICAL STATISTICS, J.E.Freund, fifth edition, Prentice Hall of India, New Delhi, 1978

INTERNET RESOURCES

1. https://jam.iisc.ac.in/p/mathematical-statistics-ms-1
2. https://ocw.mit.edu/courses/mathematics/18-655-mathematical-statistics-spring-2016/
3. https://www.khanacademy.org/math/statistics-probability

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			COURSE LEVEL OUTCOMES (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	1	Disciplinary knowledge	✓	✓	✓		✓	
	2	Communication skills	✓		✓			✓
	3	Critical thinking		✓	✓		✓	✓
	4	Research related skills	✓			✓	✓	✓
	5	Analytical reasoning		✓	✓	✓	✓	✓
	6	Problem solving		✓	✓	✓	✓	✓
	7	Team work			✓		✓	✓
	8	Moral and ethical awareness					✓	✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	III	21MMA35E	OBJECT ORIENTED PROGRAMMING WITH C++	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Discuss about the basic concepts of OOPS, tokens, expressions and control structures.
2.Explain about various functions, classes and objects in programs.
3.Exercise constructors and destructors suitably in a program.
4.Analyze overloading operators, type conversions and to use the idea of inheritance to develop reusability concepts in OOPS.
5.Describe the concepts of pointers, virtual functions and to implement in programs wisely.
6. Discover the applications of C++ programs.

UNIT: I

Basic concepts of Object–Oriented Programming – Benefits of OOP- Applications of OOP. Beginning with C++. Tokens, Expressions and Control structures.
(Chapter 1 – Sections: 1.5, 1.6 & 1.8, Chapter 2 and Chapter 3)

UNIT: II

Functions in C++.
Classes and Objects.
(Chapter 4 and Chapter 5)

UNIT: III

Constructors and Destructors.
(Chapter 6)

UNIT: IV

Operator Overloading and Type conversions.
Inheritance: Extending Classes.
(Chapter 7 and Chapter 8)

UNIT: V

Pointers, Virtual Functions and Polymorphism.
(Chapter 9)

PEDAGOGY STRATEGIES

- Board and Chalk lecture
- Power point slide presentations
- Assignments
- Quiz
- Seminars
- Group Discussions

REFERENCES:

OBJECT ORIENTED PROGRAMMING WITH C++ , E. Balagurusamy, Fourth Edition, Tata McGraw Hill Publishing Company, New Delhi, 2008.

FURTHER READING:

1. Object Oriented Programming In TurboC++ –Robert Lafore, Wate group, 1992.
2. The C++ Programming Language– BjarneStroustroup, Addison Wesley, 1991.

INTERNET RESOURCES

- https://www.geeksforgeeks.org/
- https://www.tutorialspoint.com/cplusplus/cpp_functions.htm
- https://www.geeksforgeeks.org/difference-between-constructor-and-destructor-in-c/
- https://www.softwaretestinghelp.com/types-of-inheritance-in-cpp/

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Core Course Level Outcomes (CLO)					
			1	2	3	4	5	6
Programme Level outcomes (PLO)	1	Disciplinary Knowledge	✓		✓	✓		✓
	2	Communication Skills		✓	✓		✓	
	3	Critical Thinking	✓			✓	✓	
	4	Research Related Skills	✓	✓			✓	✓
	5	Analytical Reasoning		✓		✓		✓
	6	Problem Solving				✓		✓
	7	Team Work	✓		✓		✓	
	8	Moral and ethical awareness		✓	✓		✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	IV	21MMA41C	OPERATER THEORY	6

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Classify bounded and unbounded linear operators, discuss the properties of bounded linear operators on Hilbert spaces and compute the square root of positive Operators.
2. Discuss Polar decomposition of Normal and Non-normal Operators.
3. Discover the spectral results of specific kind of operators.
4. Classify the several classes of non-normal operators and convexoid operators in function spaces.
5. Distinguish important inequalities and appraise the Aluthge transformation of p-hyponormal operators.

UNIT: I

FUNDAMENTAL PROPERTIES OF BOUNDED LINEAR OPERATORS: Bounded linear operator on a Hilbert space - Norm of a bounded linear operator – Adjoint operator – Generalized polarization identity and its application – Several properties on projection operator – Generalized Schwarz inequality and square root of positive operator – Spectral representations of self-adjoint operator.

(Chapter 2 - Section: 2.1)

UNIT: II

PARTIAL ISOMETRY OPERATOR: Partial isometry operator and its characterization

POLAR DECOMPOSITION OF AN OPERATOR: Invariant subspace and reducing subspace – Polar decomposition of non-normal operator – Hereditary property on the polar decomposition of an operator.

(Chapter 2 - Sections: 2.2 and 2.3)

UNIT: III

SPECTRUM OF AN OPERATOR: Two kinds of classification of spectrum – Spectral mapping theorem.

NUMERICAL RANGE OF AN OPERATOR: Numerical range is a convex set – Numerical radius is equivalent to operator norm – The closure of numerical range includes the spectrum – Normaloid operator and spectraloid operator.

(Chapter 2 - Sections: 2.4 and 2.5)

UNIT: IV

RELATIONS AMONG SEVERAL CLASSES OF NON-NORMAL OPERATORS: Paranormal operators – Implication relations among several classes of non-normal operators.

CHARACTERIZATIONS OF CONVEXOID OPERATORS AND RELATED EXAMPLES: Charecterization of convexoid operators-Some examples related to hyponormal, paranormal, normaloid and convexoid operators.

(Chapter 2 - Sections: 2.6 and 2.7)

UNIT: V

FURTHER DEVELOPMENT OF BOUNDED LINEAR OPERATORS: Young inequality and Holder – McCarthy inequality – Löwner-Heinz Inequality and Furuta Inequality – Chaotic order and the Relative operator Entropy– Aluthge transformation on p-hyponormal operators and log-hyponormal operators.

(Chapter 3 - Sections: 3.1 to 3.4)

PEDAGOGY STRATEGIES:

- Board and Chalk Lecture
- PowerPoint slide presentations
- Assignments
- Seminars
- Quizzes

REFERENCE:

INVITATION TO LINEAR OPERATORS– TAKAYUKI FURUTA,Taylor and Francis Group, 2001.

FUTHER READING:

1. **HILBERT SPACE PROBLEM BOOK** – P.R.HALMOS, Springer Verlag, New York.
2. **THEORY OF OPERATOR ALGEBRAS** - M. Takesaki, Springer 2012

INTERNET RESOURCES:

1. https://youtu.be/-7RItl2EA30
2. https://en.wikipedia.org/wiki/Operator_topologies

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)				
			1	2	3	4	5
Program Level Outcomes (PLO)	1	Disciplinary knowledge	✓	✓	✓	✓	✓
	2	Communication skills					
	3	Critical thinking	✓	✓	✓	✓	✓
	4	Research related skills	✓	✓	✓	✓	✓
	5	Analytical reasoning	✓	✓	✓	✓	✓
	6	Problem solving	✓	✓	✓	✓	✓
	7	Team work	✓	✓			
	8	Moral and ethical awareness		✓		✓	

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-2022 onwards	IV	21MMA42C	FLUID DYNAMICS	5

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1.Apply the basic applied-mathematical tools that support fluid dynamics.
2.Identify and obtain the values of fluid properties and relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.
3.Recognize these principles written in form of mathematical equations.
4.Apply dimensional analysis to predict physical parameters that influence the flow in fluid Mechanics.
5.Compute the lift, drag, and moments acting on simple aerodynamic profiles and shapes in inviscid, steady fluid flows.
6.Organize the real life application in different situations.

UNIT: I

KINEMATICS OF FLUIDS: Methods of describing fluid motion; Lagrangian method – Eulerian method – Translation, Rotation and rate of deformation – Streamlines, path lines and streak lines –The Material derivatives and acceleration –Vorticity.

FUNDAMENTAL EQUATIONS OF THE FLOW OF VISCOUS COMPRESSIBLE FLUIDS: The equation of continuity – Conservation of mass –The equation of motion – Conservation of momentum, The equation of energy –Conservation of energy, Fundamental equations in cylindrical coordinates.
(Chapter 3 - Sections: 3.1, 3.1a, 3.1b, 3.2, 3.3a, 3.3b, 3.3c, 3.4, 3.5 and
Chapter 5 -Sections: 5.1 to 5.3,5.5)

UNIT: II

ONE DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW: The equation of continuity –Stream tube flow; equation of motion – Euler's equation – The Bernoulli's equation – Flow from a tank through a small orifice – Trajectory of a free jet – The momentum theorem-Applications of the momentum theorem.

TWO AND THREE DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW: Equation of continuity – Eulerian equation of motion - Circulation theorem (Kelvin's) – Velocity potential – Irrotational flow – Integration of the equations of motion – Bernoulli's equation – The momentum theorem – The moment of momentum theorem.
(Chapter 6 - Sections: 6.1 to 6.3, 6.4a, 6.4b, 6.6,6.7 and
Chapter 7 – Sections: 7.1, 7.2, 7.3a, 7.3b, 7.3c, 7.4, 7.5, 7.5a, 7.5b, 7.6, 7.7)

UNIT: III

Laplace equation – Boundary conditions – Stream function in two dimensional motion – The flow net – Stream function in three dimensional motion – two dimensional flow examples – Rectilinear flow – Source and sink – Radial flow –Vortex flow – Doublet – Three dimensional axially symmetric flow –Uniform flow – Radial flow – Radial flow (source or sink) – Doublet-Motion of solid bodies in a fluid.
(Chapter 7 - Sections: 7.8a, 7.8b, 7.9 to7.11, 7.12a, 7.12b, 7.12c, 7.12d, 7.13a, 7.13b,7.13c,C)

UNIT: IV

LAMINAR FLOW OF VISCOUS INCOMPRESSIBLE FLUIDS: Similarity of flows – The Reynolds number –Viscosity from the point of view of the kinetic theory– Flow between parallel flat plates – Couette flow –Plane Poiseuille flow – Steady flow in pipes – Flow through a pipe – The Hagen-Poiseuille flow – Flow between coaxial cylinders.
(Chapter 8 - Sections: 8.1,8.2, 8.3, 8.3a, 8.3b, 8.4a and 8.4b)

UNIT: V

BOUNDARY LAYER THEORY: Properties of the Navier–Stokes Equations -Boundary layer concept – The Boundary layer equations in two dimensional flow –The Boundary layer along a flat plate – The Blasius solution – Shearing Stress and Boundary layer thickness – Boundary layer on a surface with pressure gradient –Momentum integral theorem for the boundary layer – The Von Karman Integral Relation- Von Karman Integral Relation by Momentum law.

(Chapter 9 - Sections: 9.1, 9.2, 9.3a, 9.3b, 9.4, 9.5a,9.5b)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Quizes
- Seminars

REFERENCE:

FOUNDATION OF FLUID MECHANICS – S.W.YUAN, Prentice Hall of India Private Limited, 1988.

FURTHER READING:

1.MODERN FLUID DYNAMICS -N.CURLE and H.J.DAVIES, Volume I, D.VanNostrand Company Limited, London, 1968

2. TEXT BOOK OF FLUID DYNAMICS – F.CHORLTON, CBS Publishers, New Delhi,2004.

INTERNET RESOURCES:

1.https;//nptel.ac.in/courses/112/106/112106200/

2. https;//nptel.ac.in/courses/112/105/112105171/

MAPPING OF PROGRAMME LEVEL OUTCOMES WITH CORE COURSE LEVEL OUTCOMES.

			Course Level Outcomes (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	**1**	**Disciplinary knowledge**	✓		✓		✓	✓
	2	**Communication skills**		✓		✓		✓
	3	**Critical thinking**	✓	✓			✓	
	4	**Research related skills**	✓		✓	✓		✓
	5	**Analytical reasoning**	✓	✓		✓		
	6	**Problem solving**	✓		✓		✓	✓
	7	**Team work**		✓	✓	✓	✓	
	8	**Moral and ethical awareness**	✓	✓		✓	✓	✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	IV	21MMA43C	FUZZY LOGIC AND FUZZY SETS	5

COURSE LEVEL OUTCOMES:

On the successful completion of the course, student will be able to:

1. Differentiate crisp set and fuzzy set.
2. Define the operations of fuzzy sets.
3. Discuss the relations in fuzzy set theory and measure theory.
4. Explain the application of fuzzy sets in information theory.
5. Apply the concept of fuzzy set theory in real life.

UNIT: I

CRISP SETS AND FUZZY SETS: The notion of Fuzzy sets – Basic concepts of Fuzzy sets.
OPERATIONS ON FUZZY SETS: Fuzzy Complement – Fuzzy Union – Fuzzy Intersection – Combination of operations – General aggregation operations.
(Chapter 1 - Sections: 1.3 and 1.4; Chapter 2 - Sections: 2.2 to 2.6)

UNIT: II
FUZZY RELATIONS: Crisp and Fuzzy relations – Binary relations – Binary relations on a single set – Equivalence and similarity relation – Compatibility or tolerance relations – Orderings – Morphisms – Fuzzy relation equations.
(Chapter 3 - Sections: 3.1 to 3.8)

UNIT: III
FUZZY MEASURES: General discussion – Belief and Plausibility measures – Probability measures – Possibility and Necessity measures – Relation among classes of fuzzy measures.
(Chapter 4 - Sections: 4.1 to 4.5)

UNIT: IV
UNCERTAINTY AND INFORMATION: Types of uncertainty – Measures of fuzziness, Classical measures of uncertainty – Measures of dissonance – Measures of Confusion and Nonspecificity.
(Chapter 5 – Sections: 5.1 to 5.6)

UNIT: V APPLICATIONS: General discussion – Natural life and Social Sciences – Engineering – Medicine - Management and Decision making – Computer Science. (Chapter 6 - Sections: 6.1 - 6.6)

PEDAGOGY STRATEGIES

- Board and Chalk lecture
- Power point slide presentations
- Seminar
- Assignments
- Quizes

REFERENCES:

FUZZY SETS, UNCERTAINTY AND INFORMATION – GEORGE J.KLIR AND INA A.FOLGER, Prentice Hall of India, New Delhi, 2007.

FURTHER READING:

1. FUZZY SETS AND FUZZY LOGIC THEORY AND APPLICATIONS – GEORGE J.KLIR AND BO YUAN, Prentice Hall of India, New Delhi, 2006.
2. FUZZY LOGIC WITH ENGINEERING APPLICATIONS - Timothy J. ROSS WILLEY, India Pvt. Ltd., New Delhi, Second Edition Reprint, 2009.

INTERNET RESOURCES

- http://www.b-farhadinia.ir/bfarhadiadmin/file/stdfile/Klir.pdf
- http://iauctb.ac.ir/Files/%D9%88%D8%A8%20%D8%B3%D8%A7%DB%8C%D8%AA%20%D8%A7%D8%B3%D8%A7%D8%AA%DB%8C%D8%AF/fuzzy%20logic%20with%20engineering%20application-3rdEdition.pdf

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)				
			1	2	3	4	5
Programme Level Outcomes (PLO)	1	Disciplinary Knowledge	✓	✓	✓		
	2	Communication Skills			✓	✓	✓
	3	Critical Thinking				✓	✓
	4	Analytical reasoning	✓	✓	✓		
	5	Research- related skills				✓	✓
	6	Problem Solving		✓	✓	✓	✓
	7	Team work				✓	✓
	8	Multicultural Competence				✓	✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	IV	21MMA44C	CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS	5

EXPECTED COURSE OUTCOMES

On successful completion of the course, student will be able to:

1. Define Euler Equation for finding extremals of Functionals of Higher Order Derivatives.
2. Discuss the variational problems with moving boundaries in the Light transmission.
3. Solve the initial value and Boundary value problems.
4. Analyze orthogonality and reality of Eigen Functions.
5. Compare the Solution of Fredholm, Vollerra integral equations of second kind by successive substitutions, Approximation method.
6. Evaluate the symmetric integral Equations using Hilbert Schmidt theory.

UNIT: I

VARIATIONAL PROBLEMS WITH FIXED BOUNDARIES: The concept of variation and its properties – Euler's equation – Variational problems for functional – Functional dependent on higher order derivatives – Functions of several independent variables – Some applications to problems of mechanics
(Chapter 1 - Sections: 1.1 to 1.5 and 1.7)

UNIT: II

VARIATIONAL PROBLEMS WITH MOVING BOUNDARIES: Variational problem with a movable boundary for a functional dependent on two functions - One-sided variations - Reflection and Refraction of extremals - Diffraction of light rays.
(Chapter 2 – Section: 2.2 to 2.5)

UNIT: III

INTEGRAL EQUATIONS: Introduction – Types of Kernels - Eigen Values and Eigen function – Connection with differential equation –Differentiation under sign of integration (Leibnitz rue) - Solution of Integral Equation – Initial Value Problems - Boundary value problems.
(Chapter 1 - Sections: 1.1 to 1.3 - 1.8)

UNIT: IV

SOLUTION OF FREDHOLM INTEGRAL EQUATIONS: Second kind with separable kernel- Orthogonality and reality of Eigen functions - Fredholm Integral Equation with separable kernel - Solution of Fredholm integral equation of the second kind by successive

substitution and Approximation - Solution of Volterra integral equation of the second kind by successive substitution and Neumann series.

(Chapter 2 - Sections: 2.1 to 2.3 and Chapter 4 - Sections: 4.1 to 4.4, 4.7)

UNIT: V

HILBERT - SCHMIDT THEORY: Complex Hilbert space - Orthonormal system of functions – Gram-Schmidt orthogonalization process - Hilbert – Schmidt theorem- Solution of Fredholm Integral Equation of First kind.

(Chapter 3 - Section 3.1 to 3.4 and 3.8, 3.9)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Power point slide presentation
- Seminar
- Assignments
- Group Discussions

REFERENCES:

1. CALCULUS OF VARIATIONS WITH APPLICATION -A.S. GUPTA, PHI Learning Pvt Ltd, New Delhi, 2011.
2. INTEGRAL EQUATIONS AND BOUNDARY VALUE PROBLEMS - SUDIR K.PUNDIR and RIMPLE PUNDIR, Pragati Prakasam, Meerut, 2005.

FURTHER READINGS:

1. METHODS OF APPLIED MATHEMATICS - F.B. HILDEBRAND, Prentice-Hall of India Pvt. New Delhi, 1968.
2. LINEAR INTEGRAL EQUATIONS - R.P. KANWAL, Theory and Techniques, Academic press, New York, 1971.
3. DIFFERENTIAL EQUATIONS AND CALCULUS OF VARIATIONS - L.ELSGOLTS, Mir Publications, Moscow, 1973.

INTERNET RESOURCES:

https://mathworld.wolfram.com/IntegralEquation.html
https://nptel.ac.in/courses/111/104/111104025/

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)				
			1	2	3	4	5
Programme Level Outcomes (PLO)	1	Disciplinary Knowledge	✓	✓	✓	✓	
	2	Communication Skills			✓		✓
	3	Critical Thinking				✓	✓
	4	Analytical reasoning	✓	✓	✓		
	5	Research- related skills	✓			✓	✓
	6	Problem Solving		✓	✓	✓	✓
	7	Team work	✓			✓	✓
	8	Multicultural Competence	✓	✓		✓	✓

YEAR	SEM.	SUBJECT CODE	TITLE OF THE PAPER	Hours/ Week
2021-22 onwards	IV	21MMA45E	MATLAB	5

COURSE LEARNING OUTCOMES:

1. Identify a software package for high–performance numerical computation and visualization
2. Discuss the basic concepts of MATLAB and also able to working with the arrays, matrices and anonymous functions.
3. Illustrate the matrix operations and using built-in-functions and to know about plotting a graph.
4. Develop the script files, m- files and how to use functions for specific applications
5. Explain the set of tools that used for solving the integrals and differentiation problems
6. Describe the tools that facilitates for evaluating and creating the MATLAB's applications.

UNIT: I

Introdudction – MATLAB Definition- Symbolic calculations- Basics of MATLAB – Creating and working with arrays of numbers – Creating and printing simple plots – Creating, saving and executing a script file – Creating and executing a function file – Working with arrays and matrices – Working with anonymous functions – Symbolic computation.
(Chapter 1 - Section: 1.1 to 1.6 and Chapter 2 - Sections: 2.1 to 2.8)

UNIT: II

Matrices and vectors – Matrix and array operations – Character strings – A special note on array operations – Command line functions – Using built-in functions and online help – Saving and loading data – Plotting simple graphs.
(Chapter 3 -Sections: 3.1 to 3.8)

UNIT: III

Script files – Function files – Language-specific features – Advanced data objects.
(Chapter 4 -Sections: 4.1 to 4.4)

UNIT: IV

Applications – Linear algebra – Curve fitting and interpolation – Data analysis and statistics – Numerical integration – Ordinary Differential Equations – Non-linear algebraic equations.
(Chapter 5 -Sections: 5.1 to 5.6)

UNIT: V

Basic 2-D plots – Using subplot for multiple graphs – 3D plots- View- rotate view-Mesh and surface plots- The symbolic math tool box – Numeric versus symbolic computation – Getting help with the symbolic math tool box.

(Chapter 6 - Sections: 6.1, 6.2, 6.3.1 to 6.3.3; Chapter 8 - Sections: 8.1 to 8.4)

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Power point slide presentations
- Assignments
- Seminar
- Quizes

REFERENCE:

GETTING STARTED WITH MATLAB, UPDATED FOR VERSION 7.8 – RUDRAPRATAP, Oxford University Press, 2010.

FUTHER READING:

1. MATLAB, AN INTRODUCTION WITH APPLICATIONS– AMOS GILAT, Wiley Student Edition.
2. NUMERICAL COMPUTING WITH MATLAB– CLEVE B.MOLER, Web Edition, Published by the Mathworks,Inc.

INTERNET RESOURCES

1. https://www.mathworks.com/campaigns/products/trials.html
2. https://www.mathworks.com/academia/students.html

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES.

			Course Level Outcomes (CLO)					
			1	2	3	4	5	6
Program Level Outcomes (PLO)	**1**	**Disciplinary knowledge**	✓	✓			✓	
	2	**Communication skills**	✓		✓			✓
	3	**Critical thinking**		✓	✓		✓	✓
	4	**Research related skills**		✓	✓	✓	✓	
	5	**Analytical reasoning**		✓	✓	✓	✓	✓
	6	**Problem solving**		✓	✓	✓	✓	✓
	7	**Team work**		✓	✓		✓	
	8	**Moral and ethical awareness**					✓	✓

MODEL QUESTION PAPER

GOVERNMENT ARTS COLLEGE (AUTONOMOUS), COIMBATORE-18

21MMA14C **REG. NO. …….**

M.Sc., DEGREE EXAMINATIONS Month and year ……..

MATHEMATICS **SEMESTER-I**

ORDINARY DIFFERENTIAL EQUATIONS

TIME: 3 Hrs **MAX. MARKS: 50**

PART- A

I. Choose the Correct Answer $(5\times1=5\,Marks)$

1. An equation $L(y)=y''+a_1y'+a_2y=b(x)$ is said be a homogeneous equation if
   (a) $b(x)\neq0$, (b) $b(x)=0$, (c) $a_1=0$, (d) $a_1\neq0$
2. If r_1,r_2 are distinct roots of the characteristic polynomial $p(r)=r^2+a_1r+a_2=0$, then its solution is
   (a) $\phi=c_1e^{r_1x}+c_2e^{r_2x}$, (b) $\phi=c_1e^{-r_1x}+c_2e^{r_2x}$, (c) $\phi=c_1e^{r_1x}+c_2e^{-r_2x}$, (d) $\phi=c_1e^{r_1x}-c_2e^{r_2x}$
3. If ϕ_1,ϕ_2 are the solutions of a second order differential equations, also the Wronskian $W(\phi_1,\phi_2)(x)=0$, then the solutions ϕ_1,ϕ_2 are
   (a) Linearly dependent, (b) Linearly independent, (c) Converges , (d) Diverges
4. If $W(\phi_1,\phi_2,\phi_3)(x)=2e^{3x}$, then $W(\phi_1,\phi_2,\phi_3)(0)$ is
   (a) 6, (b) (3), (c) 0 , (d) 2
5. The magnitude of $\|\phi(x)\|$ with vector components $\phi(x),\phi'(x)$ is
   (a) $\|\phi(x)\|=\left[|\phi(x)|^{1/2}+|\phi'(x)|^{-1/2}\right]^{1/2}$ (b) $|\phi(x)|=\left[|\phi(x)|^2+|\phi'(x)|^2\right]^{1/2}$
   (c) $\|\phi(x)\|=\left[|\phi(x)|^2+|\phi'(x)|^2\right]^{1/2}$ (d) $\|\phi(x)\|=\left[\|\phi(x)\|^2+\|\phi'(x)\|^2\right]^{1/2}$

II. Answer any THREE Questions $(3\times2=6\,Marks)$

6. Define initial value problem for second order equations.
7. Define linearly independent of a n th order differential equation.
8. Find the roots of the equation $y'''-3y'+2y=0$.
9. What is annihilator method?
10. The solution to the initial value problem is $y=c_1e^{3x}+c_2e^{-x}$, find c_1,c_2 initially at $y(0)=0,\ y'(0)=1.$

PART- B $(5\times3=15\,Marks)$

III. Answer ALL the Questions

11 (a) State and prove the existence theorem for second order initial value problem**.**

(OR)

(b)Find the solution of the initial value problem $y''-2y'-3y=0,\ y(0)=0,y'(0)=1.$

12 (a) Prove that the solutions ϕ_1,ϕ_2 of $L(y)=0$ are linearly independent on an interval I, if and only if $W(\phi_1,\phi_2)(x)\neq0,\forall x\in I$.

(OR)

(b) If ϕ_1, ϕ_2 are two solutions of $L(y)=0$ on an interval I containing a point x_0, then prove that

$$W(\phi_1,\phi_2)(x) = e^{-a_1(x-x_0)} W(\phi_1,\phi_2)(x_0)$$

13 (a) Let ϕ_1, ϕ_2 be any two linearly independent solutions of $L(y)=0$ on an interval I. Prove that every solutions ϕ of $L(y)=0$ can be written uniquely as $\phi = c_1\phi_1 + c_2\phi_2$, where c_1, c_2 are constants.

(OR)

(b) Show that $\phi_n(x) = \sin nx$ satisfies the boundary value problem, $y'' + n^2 y = 0,\ y(0) = 0,\ y(\pi) = 0$, where $n = 0,1,2,3...$

14 (a) Solve the non-homogeneous equation $y'' - y' - 2y = e^{-x}$

(OR)

(b)State and prove the uniqueness theorem for n^{th} order initial value problem.

15 (a) Verify the set of functions defined on $-\infty < x < \infty$ linearly independent or dependent?

$$\phi_1(x) = 1, \phi_2(x) = x, \phi_3(x) = x^2$$

(OR)

(b) Find the real valued solutions of the differential equation $y'' + y = 0$

PART- C $(3 \times 8 = 24\ Marks)$

IV. Answer any THREE Questions

16. Let ϕ be any solution of $L(y) = y'' + a_1 y' + a_2 y = 0$ on an interval I containing x_0, then prove that $\forall x \in I, \| \phi(x_0) \| e^{-k|x-x_0|} \le \| \phi(x) \| \le \| \phi(x_0) \| e^{k|x-x_0|}$,

where $\|\phi(x)\| = \left[|\phi(x)|^2 + |\phi'(x)|^2 \right]^{1/2}$, $k = 1 + |a_1| + |a_2|$

17. Let $\phi_1, \phi_2, \phi_2, \cdots \phi_n$ are n solutions of $L(y)=0$ on an interval I, prove that they are linearly independent if and only if $W(\phi_1, \phi_2 \cdots \phi_n)(x) \neq 0$ for all x in I.

18. Solve the non-homogeneous equation

$$y''' + y'' + y' + y = 1, \text{which satisfies } \psi(0) = 0, \psi'(0) = 1, \psi''(0) = 0$$

19. Prove that the n solutions of $L(y) = 0, \phi_1, \phi_2, \cdots \phi_n$ are linearly independent on any interval I.

20. Using annihilator method find the particular solution of the equation $L(y) = y'' - 3y' + 2y = x^2$

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