CENTRE FOR DISTANCE AND ONLINE EDUCATION

Master of Science (M.Sc.)

Mathematics

(Online)

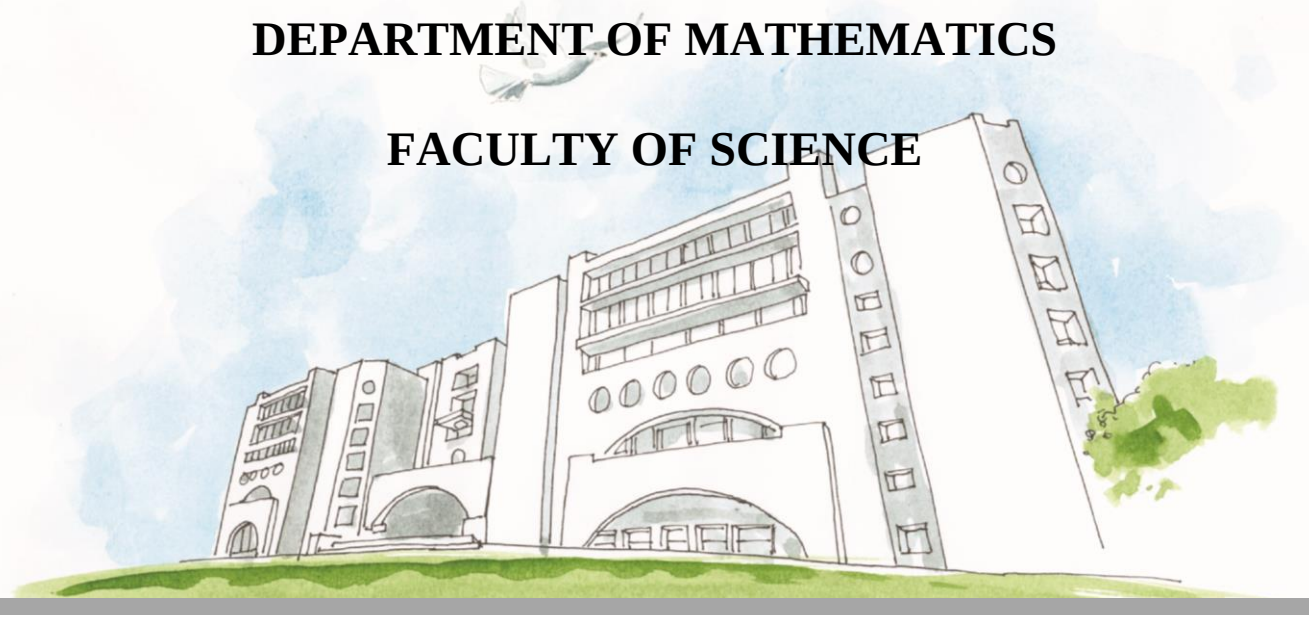
Sem I – IV

PROGRAMME STRUCTURE

TEACHING SCHEME & SYLLABI

DEPARTMENT OF MATHEMATICS

FACULTY OF SCIENCE



Marwadi University
Marwadi Chandarana Group
NAAC A+

Table of Contents

DISCOVER MARWADI UNIVERSITY

Marwadi Education Foundation's Group of Institutions (MEFGI), established in 2008 under the Bombay Public Trust Act 1950, is an organ of the Marwadi Education Foundation. It is among the 4% of Indian institutions accredited with NAAC A+ grade and only one in the Saurashtra region of Gujarat. Marwadi University is promoted by Marwadi Shares and Finance Limited (MSFL), a major stock broking company & Chandarana Intermediaries Brokers Pvt. Ltd. (CIBPL), a leading firm dealing in technical and arbitrage trading. Spread across 40 – acre campus, it is home to 9000+ students from 22+ countries enrolled in diverse programs taught by 500+ educators that include 100+ Ph.D. faculties offering a unique blend of quality education, industry connect and global exposure, at a very affordable cost in a safe and secure environment of Rajkot.

OUR VISION

To foster an environment that empowers people, organizations, and societies through education, ideas, research, and training.

OUR MISSION

- To provide quality education and thereby bring social transformation
- To create leaders through innovation and entrepreneurship
- To cultivate the culture of research advancements
- To imbibe universal consciousness
- To stimulate growth through industrial and international partnerships

OUR CORE VALUES

LEADER

- LIFELONG LEARNING
- EMPATHY
- ADAPTABILITY
- DIVERSITY
- EMPOWERMENT
- RESPECT

PROGRAMME: MASTER OF SCIENCE (MATHEMATICS) ONLINE

INTRODUCTION

A master's degree is a postgraduate qualification aimed at individuals seeking to enhance their expertise and specialization within a specific field. While bachelor's and other undergraduate degrees provide a broad overview of the subject, master's programs offer a more concentrated focus on the subject concerned, which enables students to deepen their understanding and become authorities in their chosen areas.

The M.Sc. Mathematics program is designed to establish robust foundations in both pure and applied areas of higher mathematics. It caters to students aspiring for careers in mathematical research or professions requiring advanced mathematical skills, whether in academia or industry. Through comprehensive training, students develop advanced problem-solving abilities, refine logical reasoning, and enhance computational skills, which are valuable across various domains. Moreover, the program equips students with expertise in mathematical modelling and computational techniques, making them highly desirable in the job market. To ensure relevance and alignment with industry and academic standards, the curriculum undergoes regular modification/s, based on feedback from stakeholders such as students, alumni, and parents throughout its development process. This approach ensures that graduates are well-prepared to meet the evolving demands of their chosen fields.

PROGRAMME EDUCATIONAL OBJECTIVES

- To enable students to develop mathematical logic and thinking, i.e., to formulate logical conjunctions, verify them through further exploration, and in the end, enable them to prove or disprove the same.
- To enable students to visualize scientific phenomena and experiments mathematically and quantify the results.
- To enable students to have a grasp on various mathematical structures and apply them whenever necessary.
- To enable students to understand mathematical results on their own.

- To enable students to present mathematical content simply and interestingly without losing precision hence leading them to become better educators.

PROGRAMME OUTCOMES

PO1: Science Knowledge: Apply pure and interdisciplinary science knowledge for the solution of various scientific and engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze scientific problems reaching validated conclusions using basic principles of sciences.

PO3: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO4: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern IT tools including prediction and modeling to complex scientific activities with an understanding of the limitations.

PO5: The science and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional practice.

PO6: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the scientific practice.

PO7: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO8: Communication: Communicate effectively on various activities with the Science community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO9: Science projects and funding: Demonstrate knowledge for writing and managing scientific projects various disciplines and apply these to its own work, as a member and leader in a team, to manage funding for scientific projects from various funding agencies and NGOs.

PO10: Lifelong learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES

PSO1: To enable students to present mathematical content in simple and interesting manner without losing the preciseness and hence leading them to become a better educator.

PSO2: To enable students to have grasp over various mathematical structures and apply them whenever necessary.

NATURE OF TARGET GROUP OF LEARNERS

The M.Sc. Mathematics online program offers the flexibility to pursue advanced mathematical studies from anywhere. It is designed to offer students a robust theoretical understanding alongside practical applications, equipping them for diverse career paths within the field. The program is structured to provide flexibility, enabling students to tailor their studies to their own pace and preferences, all while benefiting from the convenience of remote learning. This feature is especially beneficial for individuals with work obligations and other commitments that restrict their ability to attend conventional on-campus classes.

APPROPRIATENESS OF THE PROGRAMME WITH QUALITY ASSURANCE FOR ACQUIRING SPECIFIC SKILLS

M.Sc. Mathematics program at the Centre for Distance and Online Education (CDOE), Marwadi University offers a great opportunity for students to continue their education and enhance their skills in the field. Online Learning mode provides flexibility for students to pursue further studies while potentially balancing other commitments such as work as well as family.

By offering this program, CDOE not only contributes to the academic and professional development of its students but also aims to serve society by producing graduates with enhanced mathematical skills. With the flexibility of remote learning, students can delve deep into complex mathematical theories while balancing other commitments, making it an attractive option for those aiming for professional advancement and academic development.

Additionally, the program seems to have a positive impact on students' career prospects, with opportunities for job advancement and promotions in various occupational fields. Overall, it appears that the MU Mathematics program in the ODL mode is designed to meet the needs of students seeking to further their education and advance their careers in mathematics.

DURATION OF PROGRAMME

Minimum: 2 Years

Maximum: 4 Years

INSTRUCTIONAL DELIVERY MECHANISM

E-Content: CDOE will provide the course material in digital format to the learner which is provided to the students well in time.

PROCEDURES FOR ADMISSIONS, CURRICULUM TRANSACTION AND EVALUATION

(a) Admission Procedure

- All details concerning eligibility criteria, required documentation, and registration procedures are accessible on the website www.marwadiuniversity.ac.in.
- Candidates must verify that their educational/qualifying degrees are from recognized Institutions/Universities.
- During online registration, candidates must scan and submit all relevant documents as outlined on the MU website.
- Admission will be processed based on the information provided by the candidate, and any misrepresentation or falsification of information will result in immediate cancellation of the candidature.
- Candidates must ensure they meet the eligibility criteria for the program they intend to enrolment in.
- Submission of documents and payments to the University is contingent upon meeting the eligibility criteria outlined in the University guidelines.

(b) Eligibility

Students aspiring for admission in the M.Sc. Mathematics Online course must fulfil the conditions listed as mandatory by the institute, for admission in the course. For M.Sc. Mathematics, the candidates with the following qualifications are eligible:

- B.A./B.Sc. in Mathematics from any recognized Indian/Foreign university with 50% or above aggregate marks.
- B.Sc.(H)/B. Tech or equivalent degree with Mathematics as a compulsory subject of study with 55% or above marks or equivalent grade in the aggregate.

(c) Curriculum Transaction

The curriculum will be delivered through self-learning materials supported by various learning resources including audio, and video aids through ICT.

(d) Medium of Instruction

Medium of instruction and examination shall be in English.

(e) Evaluation Procedure

The evaluation of the Programme will consist of two parts:

i. Continuous Assessment

ii. End Semester Examination

REQUIREMENT OF THE LABORATORY SUPPORT AND LIBRARY RESOURCES

(a) Laboratory Support

The M.Sc. (Mathematics) Programme in Online Mode does not require any Laboratory Support except IT Tools.

(b) Library Resources

Marwadi University Library is fully automated with UniRP software integrated with RFID Technology. Marwadi University has an excellent library with all the necessary reference books, that are required for the course learning. Adequate online learning links and e-learning materials will also be provided to the students, which will support them in their learning process.

COST ESTIMATE OF THE PROGRAMME

For Indian Students: ₹ 18000/- per semester

For International Students: $300/- per semester

QUALITY ASSURANCE MECHANISM AND EXPECTED PROGRAMME OUTCOMES

(a) Internal Quality Assessment Cell

Marwadi University has already formed the Internal Quality Assessment Cell (IQAC). As a part of the assessment process, IQAC will periodically assess online learning course material and audio-video tutorials and will ensure the quality of learning. It will also make time-to-time changes as per the requirements of the course. As per the recommendations of the four-quadrant approach mentioned in the NEP 2020, by UGC, Marwadi University will work continuously for the smooth conduction of processes related to teaching methodology, e-learning material improvisation, assessments, etc. Marwadi University is truly committed to providing the finest platform to the learners, for the said online program.

(b) Expected Programme Outcomes

Towards the end of the programme, students will be able to

i. Develop mathematical logic and thinking, i.e., formulate logical conjunctions, verify them through further exploration, and in the end, enable them to prove or disprove the same.
ii. Visualize scientific phenomena and experiments mathematically and quantify the results.
iii. Grasp on various mathematical structures and apply them whenever necessary.
iv. Apply mathematical results to real-world problems.
v. Present mathematical content simply and interestingly without losing precision hence leading them to become a better educator.

Programme Scheme (Sem I – II)

M.Sc. (Masters of Science) Mathematics, Sem – I

Subject Code	Subject Name	Subject Type	Credits	No of Interactive Sessions		Hours of Study Material			Examination Scheme			
				Interactive Live Lecture/ Webinar	Discussion Forum	E - Tutorial (Hrs.)	E – Contents (Hrs.)	Self-Study hours including assessment	CSE	ESE	ETE	Total Marks
02MA2401	Complex Analysis	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA2403	Optimization Techniques	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA2405	Topology	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA1406	Predicate Calculus and Graph Theory	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA1407	Introduction to Measure Theory	Mandatory	5	13	32	25	25	55	30	70	NA	100

M.Sc. (Masters of Science) Mathematics, Sem – II

Subject Code	Subject Name	Subject Type	Credits	No of Interactive Sessions		Hours of Study Material			Examination Scheme			
				Interactive Live Lecture/ Webinar	Discussion Forum	E - Tutorial (Hrs.)	E – Contents (Hrs.)	Self-Study hours including assessment	CSE	ESE	ETE	Total Marks
02MA2451	Abstract Algebra	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA2453	Numerical Analysis with MATLAB Programming	Mandatory	5	13	32	25	25	55	30	40	30	100
02MA1454	Number Theory	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA1456	Partial Differential Equations	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA1457	Lebesgue Measure and Integration Theory	Mandatory	5	13	32	25	25	55	30	70	NA	100

Programme Scheme (Sem III – IV)

M.Sc. (Masters of Science) Mathematics, Sem – III

Subject Code	Subject Name	Subject Type	Credits	No of Interactive Sessions		Hours of Study Material			Examination Scheme			
				Interactive Live Lecture/ Webinar	Discussion Forum	E - Tutorial (Hrs.)	E – Contents (Hrs.)	Self-Study hours including assessment	CSE	ESE	ETE	Total Marks
02MA2501	Calculus of Variations and Integral Equations	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA2503	Financial Mathematics	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA2504	Linear Algebra	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA1506	Classical Mechanics and Relativity	Mandatory	5	13	32	25	25	55	30	70	NA	100
02MA1507	Mathematical Statistics	Mandatory	5	13	32	25	25	55	30	70	NA	100

M.Sc. (Masters of Science) Mathematics, Sem – IV

Subject Code	Subject Name	Subject Type	Credits	No of Interactive Sessions		Hours of Study Material			Examination Scheme			
				Interactive Live Lecture/ Webinar	Discussion Forum	E - Tutorial (Hrs.)	E – Contents (Hrs.)	Self-Study hours including assessment	CSE	ESE	ETE	Total Marks
02MA2551	Functional Analysis	Mandatory	5	13	32	25	25	55	30	70	---	100
02MA1556	Mathematical Modelling and Simulation	Mandatory	5	13	32	25	25	55	30	70	---	100
02MA1557	Special Functions and Integral Transforms	Mandatory	5	13	32	25	25	55	30	70	---	100
02MA2553	Image Processing and Fuzzy Logic using MATLAB	Mandatory	5	13	32	25	25	55	30	40	30	100
02MA0582	Minor Project	Elective	5	13	32	25	25	55	---	---	100	100
02MA0581	Tensor Calculus & Differential Geometry	Elective	5	13	32	25	25	55	30	70	---	100

Note: Students have to choose any one of the electives from the given two electives in semester IV. **(Total Credits: 100)**

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**I**
COURSE TITLE	**COMPLEX ANALYSIS**
COURSE CODE	**02MA2401**
COURSE CREDITS	**5**

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

1. Generalize the concept of functions, limits, continuity, differentiability and analyticity in complex variables.
2. Understand and apply the knowledge of elementary functions and harmonic functions.
3. Evaluate contour integrals, Generalize the idea of series expansions at the singular points by Laurent series and use it in complex integrations.
4. Classify zeros and singularities of complex functions.
5. Understand and apply conformal mapping and harmonic function theory in for solving complex planes and interpret them graphically.

Pre-requisite of course: Limits, continuity, differentiability, integration, convergence of sequence and series

No of Interactive Sessions		**Credits**	**Examination Scheme**			
Interactive Live Lecture/ Webinar	**Discussion Forum**		**CSE**	**ESE**	**ETE**	**Total Marks**
13	32	5	30	70	---	100

Contents: Unit	**Topics**
1.	**Complex Numbers, Functions of Complex Variables** Basic Algebraic Properties, Vectors and Modulli, Complex Conjugates, Exponential Form and nth Roots of Complex Numbers, Regions in Complex Plane, Functions of Complex Variables, Limits, Continuity and Differentiability, Cauchy-Riemann Equations, Analytic Functions, Harmonic Functions and their Conjugates, Reflection Principle
2.	**Complex Integration** Definite Integrals of Functions of Real Variable, Contours, Line Integral, Branch Cuts and ML-inequality, Simply and Multiply Connected Domains, Cauchy-Goursat Theorem and Cauchy-Integral Formula, Generalized Cauchy-Integral Formula, Liouville's Theorem, Fundamental Theorem of Algebra, Maximum Modulus Principle
3.	**Series, Singularities and Residues**

	Convergence of Sequences and Series, Taylor's Theorem, Laurent's Series, Absolute and Uniform Convergence of Power Series, Differentiation and Integration of Power Series, Uniqueness of Series Representation, Classification of Singular Points, Residues at Isolated Singular Points, Zeros of Analytic Functions, Behaviour of Functions Near Singular Points
4.	**Cauchy Residue Theorem and its applications** Cauchy's Residue Theorem, Evaluation of Integrals Involving Sine and Cosine Functions, Evaluation of Improper Integrals, An indentation Around a Branch Point, Argument Principle, Rouche Theorem
5.	**Mapping by Elementary Functions and Conformal Mapping** Linear Transformations, Bilinear (Mobius, Linear, Fractional) Transformations, Mappings by some Standard Transformations, Preservation of Angles, Scale Factors

References:

1. Complex Variables and Applications, J. W. Brown and R. V. Churchill, McGraw-Hill, Inc. 1996.
2. Functions of One Complex Variable, J. B. Conway, Narosa Publishing House, 2002.
3. Foundations of Complex Analysis, S. Ponnusamy, Narosa Publishing House, 2005.
4. Complex Variables (Theory and applications), H. S. Kasana, Prentice-Hall of India Pvt. Ltd., 2006.
5. Complex Analysis, D. Tall and I. Stewart, Cambridge University Press, 1984.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyse	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. http://people.math.gatech.edu/~cain/winter99/complex.html
2. http://mathworld.wolfram.com/ComplexAnalysis.html
3. http://mathworld.wolfram.com/ComplexDifferentiable.htmlCA

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**I**
COURSE TITLE	**OPTIMIZATION TECHNIQUES**
COURSE CODE	**02MA2403**
COURSE CREDITS	**5**

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

1. Appreciate application of integer LP problem in several areas of managerial decision-making.
2. Identify and examine situations that generate queuing problems.
3. Interpret the concept of inventory control as well as various forms and functional role of inventory.
4. Use basic concepts of calculus-based methods to obtain an optimal solution of problem that involve continuous and differential functions.
5. Understand advance procedures to solve optimization problems.

Pre-requisite of course: ---

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents: Unit	Topics
1.	**Integer Programming** Introduction, Gomorys all Integer Cutting Plane Method, Gomorys Mixed Integer Cutting Plane Method, Branch and Bound Method, 0-1 Integer Programming Problem, Applications of 0-1 Integer Programming Problem
2.	**Queuing Theory** Introduction, The Structure of a Queuing System, Performance Measures of a Queuing Systems, Probability Distributions in Queuing Systems, Classification of Queuing Models, Single Server Queuing Models
3.	**Inventory Models**

	Introduction, Inventory Costs, Economic Order Quantity, Deterministic Inventory Problems: EOQ Problem without Shortages, EOQ Problem without Shortages and Several Production Runs of Unequal Length, EOQ Problem with Shortages, EOQ Problems with Price Breaks, Application of Inventory Models
4.	**Non-Linear Programming** Introduction to NLP, Definition of NLP, Unconstrained Optimization, Optimizing Single Variable Function, Optimizing Multivariable Function, Constrained Multivariable Optimization with Equality Constraints
5.	**Modern and Classical Methods of Optimization** Constrained Multivariable Optimization with Inequality Constraints, Kuhn Tucker Conditions, Graphical Solution of Non-Linear Programming Problem, Introduction to Genetic Algorithms (GA), Introduction to Ant Colony Optimization (ACO)

References:

1. Operations Research, H. A. Taha, MacMillan Publishing Company, 2008.
2. Operations Research, K. Swaroop, P.K. Gupta and Man Mohan, S. Chand & Sons, 1978.
3. Operations Research, S. D. Sharma, Kedar Nath.
4. Operation Research: Theory and Applications, J.K. Sharma, Macmillan, 4th edition 2009.
5. Engineering Optimization: Theory and Practices, S. S. Rao, Wiley, 4th edition, 2014.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://mathworld.wolfram.com/AntColonyAlgorithm.html
2. https://www.udemy.com/course/geneticalgorithm/
3. http://www.mit.edu/~orc/resources/orlinks.html
4. http://mat.gsia.cmu.edu/
5. www.me.utexas.edu/~jensen/ORMM/frontpage/intro.html
6. http://annaunivpgmaterials.blogspot.in/2010/11/e-books.html
7. http://mathworld.wolfram.com/OperationsResearch.html

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**I**
COURSE TITLE	**TOPOLOGY**
COURSE CODE	**02MA2405**
COURSE CREDITS	**5**

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

1. Understand terms, definition and theorems related to topological spaces.
2. Demonstrate knowledge and understanding of concepts such as open and closed sets, interior, closure and boundary.
3. Create new topological spaces by using different types of topology
4. Apply fundamental concepts of topology to other areas of Science and technology.
5. Identify compact spaces, connected spaces, Hausdroff spaces, regular spaces and normal spaces.

Pre-requisite of course: ---

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents:	
Unit	**Topics**
1.	**Metric Spaces** Sets and Functions, Metric Spaces-Open and Closed Spheres, Open and Closed Sets in a Metric Space, Interior, Closure and Boundary of a Set in a Metric Space, Convergence of a Sequence in a Metric Space, Completeness and Baire's Category Theorem, Continuous Functions on Metric Spaces, Euclidean and Unitary Spaces
2.	**Topological Spaces** Topology on a Set, Open Sets and Closed Sets in a Topological Space, Neighbourhoods, Base and Sub base, Interior, Closure and Boundary of a Set in a

	Topological Space., Isolated Points, Limit Points, Interior Points, Metric Topology and Metrizable Spaces, Continuity and Homeomorphism, Subspace Topology, Order Topology, Product of Spaces, Quotient Topology, Application in Biological Systems and Geographic Information Systems
3.	**Compactness** Compact Spaces, Locally Compact Spaces, Compact Subspaces of the Real Line, Sequentially Compact Spaces, Bolzano Weierstrass Property and Totally Bounded Sets
4.	**Connectedness** Connected Spaces, Components of a Space, Connected Subspaces of the Real Line
5.	**Countability and Separation axioms** First Countable and Second Countable Spaces, T1- Spaces and Hausdroff Spaces, Regular Spaces and Normal Spaces, The Urysohn's Lemma, The Tietze Extension Theorem

References:

1. Introduction to Topology and Modern Analysis, G.F. Simmons, Wiley India Edition, 2016.
2. Topology: A First Course, J. R. Munkres, 2/e, Prentice Hall of India Pvt. Ltd. New Delhi, 2003.
3. Topology, J. N. Sharma, Krishna Prakashan Media Ltd., 2001.
4. Introduction to Topology: Pure and Applied, C. Adams & R. Franzosa, Prentice Hall, 2007.
5. An Introduction to Topology, B. Mendelson, 3rd edition, CBS Publishers and Distributors, 1985.

Suggested Theory Distribution:

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Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room

3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. http://www.nptel.ac.in/courses/111106054/
2. https://en.wikipedia.org/wiki/Topology
3. http://www.personal.psu.edu/axk29/TOPOLOGY/Chapter1.pdf
4. https://www.math.cornell.edu/~hatcher/Top/TopNotes.pdf
5. https://www.youtube.com/watch?v=4MWLTV11zeU

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**I**
COURSE TITLE	**PREDICATE CALCULUS AND GRAPH THEORY**
COURSE CODE	**02MA1406**
COURSE CREDITS	**5**

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

1. Distinguish between valid and invalid mathematical arguments.
2. Exploring one particular way of representing facts - the language of logic.
3. Identify various types of directed graphs and their properties.
4. Understand the concepts of planarity, coloring, matching and factors of graphs.
5. Deal with research problems on graph algorithms.

Pre-requisite of course: Graphs, digraphs and graph colorings

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents: Unit	Topics
1.	**Predicate Calculus** Predicates, Statement Function, Variables and Quantifiers, Predicate Formulas, Free and Bound Variables, Universe of Discourse, Inference Theory of Predicate Calculus: Valid Formulas and Equivalences, Valid Formulas involving Quantifiers, Valid Formulas involving Quantifiers, Formulas involving more than one Quantifiers
2.	**Applications of Predicate Calculus** Representing Simple Facts in Logic, Representing `instance' and `isa' Relationship, Computable Functions and Predicates, Resolution, Conversion to Clause Form, The Basis of Resolution, Resolution in Propositional Logic, The Unification Algorithm, Resolution in Predicate Logic
3.	**Directed Graphs**

	Preliminaries of Graphs, Connectedness - Acyclic Digraph, Strong Digraphs, Tournaments, Directed Trees and Binary Trees, Weighted Trees and Prefix Codes, Breadth-First Search (BFS) and Depth-First Search (DFS), Kruskals and Prims, Algorithms, Dijkstras and Floyds Algorithms
4.	**Planarity and Coloring of Graphs** Planar Graphs, Testing of Planarity, Kuratowski Theorem for Planar Graphs, Kuratowski Theorem for Planar Graphs, Random Graphs, Vertex Colouring and Upper Bounds, Chromatic Number and Chromatic Polynomial of Graphs, Brooks Theorem, Four and Five Color Problem
5.	**Matching and Factorization** Matching in Bipartite Graphs, Halls Matching Conditions, Min-Matching in Bipartite Graphs, Sets, Applications and Algorithms, Maximum Bipartite Matching, Weighted Bipartite Matching, Matching in General Graphs: Tutte's 1-factor Theorem, F-factors of Graphs, Havels and Hakimi Algorithms

References:

1 Artificial Intelligence, E. Rich, K. Knight, S. B. Nair, Tata McGraw-Hill, 2010

2 Graph Theory with Applications to Engineering and Computer Science, Narsingh Deo, Prentice- Hall, 2004.

3 Introduction to Graph Theory, Douglas B. West, Prentice Hall of India, 2002.

4 Graph Theory, F. Harary, Addition Wesley, 1969.

5 Discrete Mathematical and its Applications, Kenneth H. Rosen, TMH, 6th edition 2007.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyse	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.

3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://homepages.warwick.ac.uk/~masgax/Graph-Theory-notes.pdf
2. http://math.tut.fi/~ruohonen/GT_English.pdf
3. https://logancollinsblog.com/2018/05/26/notes-on-graph-theory/
4. https://nptel.ac.in/content/syllabus_pdf/111106050.pdf
5. https://nptel.ac.in/courses/106/105/106105192/
6. https://www.coursera.org/learn/logic-introduction

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**I**
COURSE TITLE	**INTRODUCTION TO MEASURE THEORY**
COURSE CODE	**02MA1407**
COURSE CREDITS	**5**

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

1. Understand and summarize the theoretical aspects associated with Lebesgue measure and Lebesgue integral.
2. Apply/identify/solve using concepts of measure theory, whether the given Set or function or integral is Lebesgue measurable set or Lebesgue measurable function or Lebesgue integral respectively.
3. Distinguish and analyse the properties that are satisfied by Lebesgue measurable set/ Lebesgue measurable function/ Lebesgue integral compared with ordinary set/function/integral respectively.
4. Prove or evaluate various results that are in relationship with theory of Lebesgue measure/integral.
5. Construct new sets/functions/integrals that satisfy conditions of Lebesgue measure/integral and compare them with ordinary sets/functions.

Pre-requisite of course: Elementary set theory.

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents: Unit	Topics
1.	**Fundamentals of Real Analysis** Real Numbers and its Properties, Completeness Axiom and Archimedean Property, Countable and Uncountable Sets, Partially Ordered Set and Zorns Lemma, Heine-Borel Theorem, Cantors Nested Set Theorem, Monotone Sequence of Real Numbers, Monotone Convergence Theorem for Sequences,

	Bolzano-Weierstrass Theorem, Cauchy Convergence Criterion for Sequences, Linearity and Monotonicity of Convergence of Sequences, Uniformly Continuous Functions, Increasing, Decreasing and Monotonic Real-Valued Function
2.	**Lebesgue Measure** Introduction to Measure, Algebra and Sigma Algebra of Sets, Measurable Space, Measure Space, Lebesgue Outer Measure, Lebesgue Measurable Set, The Sigma Algebra of Lebesgue Measurable Set, Properties of Lebesgue Measure and Lebesgue Measurable Set, Countable Additivity of Lebesgue Measure, Continuity of Lebesgue Measure, Borel Sets in R, Non-Measurable Set
3.	**Measurable Functions** Measure Function, Sum, Product and Composition of Measurable Functions, Properties of Measurable Function, Relation Between Continuity and Measurability of Function, Positive and Negative Parts of Function, Decomposition of Function into its Positive and Negative Parts
4.	**Characterization and Convergence of Measurable Function** Point-wise and Uniform Convergence of Real-Valued Functions, Simple Functions, Canonical Form of Simple Function, Properties of Simple Function, Simple Approximation Theorem, Littlewoods Three Principles, Egoroff's Theorem, Lusin's Theorem
5.	**Lebesgue Integration** Riemann Integration and Lebesgue Integral of a Bounded, Measurable Function Over a Set of Finite Measure, Linearity and Monotonicity of Lebesgue Integral of a Bounded, Measurable Function over a set of Finite Measure, Bounded Convergence Theorem, Lebesgue Integral of a Non-negative Measurable Function, Chebychev's Inequality, Linearity and Monotonicity of Lebesgue Integral of a Non-Negative Measurable Function, Fatou's Lemma, Monotone Convergence Theorem, Beppo-Levis Lemma, General Lebesgue Integral and Integral Comparison Test, Linearity and Monotonicity of General Lebesgue Integral, Additivity of General Lebesgue Integral over Domain of Integration, Lebesgue Dominated Convergence Theorem, Relation of General Lebesgue Integral with Almost Everywhere Convergence of Sequence of Functions, Generalization of Lebesgue Dominated Convergence Theorem

References:

1. Real Analysis, H.L. Royden, P.M. Fitzpatrick, Pearson 4th edition, 2010.
2. Real Analysis, H.L. Royden, Macmillan Publishing Company, 3rd edition, 1988.
3. An Introduction to Measure and Integration, I.K. Rana, Narosa Publishing House, 2004.
4. Theory of Functions of a Real Variable, I. P. Natanson, Vol. I, Frederick Ungar Publishing Co., 1964.

5. Real and Complex Analysis, Walter Rudin, Tata-Mc Graw-Hill Publishing Co. Ltd., 1987.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. http://www.math.hmc.edu/~su/math131/

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**II**
COURSE TITLE	**NUMBER THEORY**
COURSE CODE	**02MA1454**
COURSE CREDITS	**5**

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

1. Solve problems involving Divisibility, The Greatest Common divisor, Euclidean Algorithm and Fundamental Theorem of Arithmetic.
2. Use theory of Congruences to solve problems.
3. Apply Chinese Remainder theorem to solve problems.
4. Use basic Number Theoretic Functions to solve the problems
5. Apply Euler's criterion to check solvability of quadratic congruences

Pre-requisite of course: ---

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents: Unit	Topics
1.	**Divisibility Theory, Prime distribution** Division Algorithm, Greatest Common Divisor, The Euclidean Algorithm, The Diophantine Equation, Properties of Primes, Fundamental Theorem of Arithmetic, Euclid's Theorem, Distribution of Primes
2.	**The Theory of Congruences** Basic Properties, Special Divisibility Tests, Linear Congruences and their Solution, Chinese Remainder Theorem, Fermat's Little Theorem, Wilson's Theorem and its Applications
3.	**The Number Theoretic Functions** The functions and the greatest integer function, Mobius Inversion Formula, Euler's Phi Function, Euler's Theorem, Some Properties of Phi Function

4.	**Primitive Roots and Indices** The Order of an Integer Modulo n, Primitive Roots of Primes, Lagrange's Theorem, Composite Numbers having Primitive Roots, The Theory of Indices
5.	**Quadratic Congruences** Euler's Criterion, The Legendre's Symbol, Gauss Lemma, Quadratic Reciprocity Law, Quadratic Congruences with Composite Moduli

References:

1. An Introduction to the Theory of Numbers, Ivan Niven, H. S. Zuckerman, H.L. Montgomery, John Wiley & Sons Inc., 1991.
2. Elementary Number Theory, David M. Burton, Tata McGraw- Hill Publishing Co. Ltd, 2010.
3. A Concise Introduction to the Theory of Numbers, Alan Baker, Cambridge University Press, 1984.
4. An Introduction to the Theory of Numbers, G.H. Hardy and E.M. Wright, Oxford University Press, London, 1975.
5. Advanced Number Theory, Harvey Cohn, Dover publication Inc, 1962.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. . https://en.wikipedia.org/wiki/Number_theory
2. https://www.britannica.com/topic/number-theor
3. http://mathworld.wolfram.com/topics/NumberTheory.html

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**II**
COURSE TITLE	**PARTIAL DIFFERENTIAL EQUATIONS**
COURSE CODE	**02MA1456**
COURSE CREDITS	**5**

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

1. Classify different partial differential equations and form partial differential equations.
2. Solve linear and non-linear 1st order PDE
3. Evaluate higher order partial differential equations.
4. Classify the second order partial differential equations and reduce them to normal form.
5. Applying concepts of partial differential equations by formulating and solving heat, wave and Laplace equation.

Pre-requisite of course: Partial differentiation, Integral and differential calculus, Ordinary differential equations.

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents:	
Unit	**Topics**
1.	**Introduction to Partial Differential Equations** Definitions, Classification of First Order PDE's, Formation of PDE, Initial and Boundary Conditions, Cauchy's Problem for First Order Equations, Types of Solution
2.	**Solution of First Order PDE's** The Method of Characteristics, Lagrange's Method, Charpit's Method, Cauchy's Problem for First Order PDE, Some Special Form of Equations
3.	**Solution of Second and Higher Order PDE's**

	Homogeneous Linear PDE's with Constant Coefficients, Method for Finding Complementary Function, Particular Integral of Homogeneous PDE, PDE's Reducible to Equations with Constant Coefficients (Euler-Cauchy Type Equations)
4.	**Classification of Second Order PDE's** PDE of Second Order with Variable Coefficients, Solution of Second Order PDE under given Geometrical Conditions, Classification of Linear PDE of Second Order, Reduction of Hyperbolic, Parabolic and Elliptic Equation to its Canonical Form
5.	**Applications of Partial Differential Equations** Method of Separation of Variables, Heat Equation, Laplace Equation, Wave Equation, Cauchy Initial Value Problem for Linear First Order PDE

Textbooks:

1. An Elementary Course in Partial Differential Equations, T. Amarnath, Narosa Publishing House, 1997.
2. Elements of Partial Differential Equations, I. N. Sneddon, McGraw-Hill Company, 1957.

References:

1. Partial Differential Equations, , L. C. Evans, Graduate Studies in Mathematics,, 1998.
2. Ordinary and Partial Differential Equations, M. D. Raisinghania, S. Chand, S. Chand Publishing, 2013.
3. Introduction to Partial Differential Equations, K. S. Rao, PHI Learning Pvt. Ltd, 2010.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room

3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://nptel.ac.in/courses/111/103/111103021/
2. https://www.youtube.com/watch?v=ly4S0oi3Yz8
3. https://swayam.gov.in/nd1_noc20_ma12/preview

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**II**
COURSE TITLE	**LEBESGUE MEASURE AND INTEGRATION THEORY**
COURSE CODE	**02MA1457**
COURSE CREDITS	**5**

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

1. Understand the concepts related to general Lebesgue integral of functions and their properties, for real line and like-wise general spaces.
2. Apply theory of Lebesgue integral on various functions and analyse their properties.
3. Analyse the theory for Lebesgue integral associated with general measure spaces.
4. Evaluate theoretical problems associated with general Lebesgue integral and their properties.
5. Create new abstract measure spaces and study their properties in terms of Lebesgue integral.

Pre-requisite of course: - Limit & Continuity.

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents:	
Unit	**Topics**
1.	**Lebesgue Integration** The General Lebesgue Integral, The Integral Comparison Test, Linearity and Monotonicity of Integration, The Lebesgue Dominated Convergence Theorem, General Lebesgue Dominated Convergence Theorem, Countable Additivity and Continuity of Integration, The Countable Addi- tivity of Integration, Continuity of Integration, The Vitae Convergence Theorem, Family of Tight Measurable Functions, The Generalized Vitalis Convergence Theorem, Convergence in Measure, Rieszs Theorem, Characterization of Riemann and Lebesgue Integrability
2.	**Differentiation and Integration in Lebesgue Theory**

	Continuity of Monotone Function, Differentiability of Monotone Functions, The Vitali Covering Lemma, Upper and Lower Derivatives of Real Valued Function, Lebesgue Theorem, Divided Difference Function, Average Value Function, Total Variation of a Function, Function of Bounded Variation, Jordan Theorem, Jordan Decomposition of a Function, Absolutely Continuous Function, Fundamental Theorem of Integral Calculus for Lebesgue Integral, Singular Function, Lebesgue Decomposition of a Function
3.	**The Lp − Spaces: Completeness and Approximation** Linear Space, Subspace of a Linear Space, Essentially Bounded Function, Norm of an Element in Linear Space, Normed Linear Space, Unit Function, Normalization of a Function, Conjugate of a Number, Youngs Inequality, Holders Inequality, Minkowski's Inequality, Cauchy-Schwarz Inequality, Convergence in Normed Linear Space, Cauchy Sequence in Normed Linear Space, Banach Space, Rapidly Cauchy Sequence, The Riesz-Fischer Theorem, Dense set in Normed Linear Space, Separable Normed Linear Space
4.	**Duality in L_p − Spaces** Linear Functional, Bounded Linear Functional, Dual Space, The Riesz Representation Theorem for the Dual of $Lp(E)$
5.	**General Measure Spaces** Measurable Space, Measure Space, Counting Space and Dirac Space, Continuity of Measure, Borel-Cantelli Lemma, Finite Measure and infinite Measure, Complete Measure Space, Signed Measure, Positive Measure and Negative Measure, The Hahn Decomposition Theorem, The Jordan Decomposition Theorem

References:

1. Real Analysis, H. L. Royden, P.M. Fitzpatrick, Pearson, 4th Edition, 2010.
2. Measure theory, D. H. Fremlin, Cambridge University Press, 2001.
3. Measure and Integration, G. D. De Barra, Wiley Eastern Limited, 1981.
4. Measure Theory, P. R. Halmos, Van Nostrand Publishers, 1979.
5. Real and Complex Analysis, Walter Rudin, Tata-Mc Graw-Hill, 1987.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process.

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**II**
COURSE TITLE	**ABSTRACT ALGEBRA**
COURSE CODE	**02MA2451**
COURSE CREDITS	**5**

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

1. Apply Sylow's theorem/s to identify the structure of groups.
2. Demonstrate the properties of groups, rings and fields.
3. Analyse the structure of polynomial rings and extension fields.
4. Decide the reducibility and irreducibility of a polynomial over a field.
5. Discuss the solvability of polynomials using Galois Theory.

Pre-requisite of course: Elementary Number Theory

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents:	
Unit	**Topics**
1.	**Structure Theory of Groups** Direct products and Fundamental Theorem of finite abelian groups, Conjugacy class, Normalizer and Class equation, Center of a group, Cauchy Theorem for abelian and non-abelian groups, Sylow Theorem for abelian and non-abelian groups
2.	**Special Kinds of Rings** Definition and examples of rings, Characteristic of a ring, Zero divisors, Integral domain and Field, Homomorphism and Quotient ring, Subring and Ideal, Principal

	ideal, Prime ideal and Maximal ideal, Irreducible element and Prime element, Euclidean domain, Principal ideal Domain and Unique factorization Domain
3.	**Polynomial Rings** Definition and Examples, Division algorithm and its consequences, Irreducible and reducible polynomial, Reducibility tests, Primitive polynomial, Monic polynomial, and Gauss Lemma, Irreducibility tests – Eisenstein's criterion and Mod p irreducibility test
4.	**Extension Field** Extension field, Finite extension, Simple extension, Algebraic and Transcendental extension, Minimal polynomial, Splitting fields
5.	**Galois Theory** Automorphism groups, Fixed fields and Galois group, Normal extension and Fundamental Theorem of Galois theory, Solvability by radicals, Solvable groups, Abel's theorem

References:

1. Topics in Algebra, I. N. Herstein, Willey Eastern Ltd., New Delhi, 1999.
2. Contemporary Abstract Algebra, J.A. Gallian, Narosa Publishing House, 2009.
3. Basic Abstract Algebra, P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, 2nd Edition, Cambridge University Press, 1995.
4. Algebra, Algebra, M. Artin, Prentice – Hall of India Private Ltd., New Delhi, 1994.
5. Abstract Algebra, D. S. Dummit and R. M. Foote, Wiley Ltd., 2004.
6. Abstract Algebra, I. H. Sheth, 2nd Edition, PHI Learning Private Ltd., 2009.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyse	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room

3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://en.wikibooks.org/wiki/Abstract_Algebra
2. http://www.math.niu.edu/~beachy/abstract_algebra/
3. http://abstract.ups.edu/download.html
4. http://www.math.umn.edu/~garrett/m/algebra/
5. https://www.youtube.com/watch?v=7gE8VxQxHQM

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**II**
COURSE TITLE	**NUMERICAL ANALYSIS WITH MATLAB PROGRAMMING**
COURSE CODE	**02MA2453**
COURSE CREDITS	**5**

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

1. Understanding what roots problems are and where they occur in engineering and science.
2. Knowing solution of a system of linear algebraic equations and the mathematical definition of eigenvalues and eigenvectors.
3. Find the equation of the curve of best fit which may be most suitable for predicting the unknown values.
4. Understanding the application numerical differentiation and integration formulas.
5. Knowing how to solve problems in science and technology with differential equation.

Pre-requisite of course: Integral calculus, differential calculus, ordinary differential equations.

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	---	100

Contents:	
Unit	**Topics**
1.	**Solution Transcendental and Polynomial Equations** Number Representation in Computers, Floating Point Arithmetic, Various Types of Errors Encountered in Computations, Roots of Equation: Open and Bracketing Methods, Graeffes Root-Squaring Method, Fixed Point Iterations, Ramanujan's Method

2.	**Numerical Linear Algebra** Gauss Elimination with or without Pivoting and Gauss Seidel, Condition Number and Ill Conditioned Linear Systems, LU Factorization-Crouts and Cholesky Methods, Tri-diagonal System of Equations - Thomas Algorithm, Newton-Raphson for Non-linear System of Equations, Eigen Values Problem-Power method, Jacobi Method, Singular Value Decomposition (SVD)
3.	**Curve Fitting** Introduction, Principle of Least Squares and Method of Least Squares, Fitting a Curve of the Parabola Types, Fitting of Exponential Curves
4.	**Interpolation and Integration** Interpolation with Unequal Intervals, Newtons Divided Difference Formula, Hermite's Interpolation Formula, Spline Interpolation-Cubic Spline, Gaussian Quadrature Method, Romberg Method
5.	**Numerical Solution of Differential Equations** Introduction, Modified Euler Method, 4th Order Runge-Kutta Method, Predictor Corrector Methods, Finite Difference Method for Boundary Value Problem, Solution of PDE: Classification of 2nd Order Equations, Finite Difference Approximations to Partial Derivatives, Elliptic Equations (Laplace and Poisson Equation)

List of Experiments:

Unit	Topics
1.	**Solution Transcendental and Polynomial Equations** An Overview of MATLAB, Roots of Equation: Bracketing Methods
2.	**Numerical Linear Algebra** Roots of Equation: Open Methods, Gauss Elimination Method
3.	**Curve Fitting** Gauss Siedel Iteration Method, Factorization Method Power Method
4.	**Interpolation and Integration** Method of Least Squares, Newtons Divided Difference Formula
5.	**Numerical Solution of Differential Equations** Simpson's Rule, Modified Euler's Method, Runge-Kutta Method

Practical Requirements: Student has to register with institutional Email Id in https://www.mathworks.com/products/matlab-online/limitations.html

Textbook:

1. Numerical Methods in Engineering & Science with Programs in C, C++, & MATLAB, B. S. Grewa, l, Khanna Publishers, 2015.
2. Numerical Methods for Scientific and Engineering Computations, , M. K. Jain, S. R. K. Iyengar & R. K. Jain, , New Age International, 2004.
3. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall India Learning Private Limited, 2012.

References:

1. Numerical Methods for Mathematics & Science, J. H Mathews, Prentice Hall,, 1992.
2. Applied Numerical Methods with MATLAB for Engineers and Scientists, S. C. Chapra, Tata Mc- Graw Hill, 2008.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. . http://mathforcollege.com/nm/resource.html
2. . https://onlinecourses-archive.nptel.ac.in/noc17_ma14/preview
3. https://swayam.gov.in/nd1_noc19_ma21/preview

4. https://www.coursera.org/learn/intro-to-numerical-analysis
5. http://vlabs.iitb.ac.in/vlabs-dev/labs/numerical_lab/labs/explist.php

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**III**
COURSE TITLE	**CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS**
COURSE CODE	**02MA2501**
COURSE CREDITS	**5**

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

1. Understand what are functionals and have some appreciation of their applications in mathematics and physics.
2. Analysing the behaviour of variational problem with different boundary conditions
3. Understand the relationship between integral and differential equations
4. Solve linear integral equations by analysing various kernels
5. Solve Strum-Liouville's equation

Pre-requisite of course: 1st and 2nd Order Ordinary Differential Equations

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Calculus of Variations** Introduction, Euler Equation and its Solution, Problem of Brachistochrone, Problem of Geodesics, Euler-Ostrogradsky Equation, System of Eulers Equation, Eulers Equation for Higher Order Derivatives
2.	**Conditions for Extrema of Functional** Sufficient Conditions for Extrema, Legendre's Condition, Isoperimetric Problem, Variational Problem with Natural Boundary Conditions, Variational Problems with Moving Boundaries and Transversality Conditions, Hamilton's Principle and Lagrange's Equation

3.	**Introduction to Integral Equations** Basic Definitions, Conversion of Linear Differential Equation into an Integral Equation, Conversion of Integral Equation into Differential Equation, Verification of Solutions of Integral Equations, Boundary Value Problems
4.	**Solution of Integral Equations** Solution of Fredholm's Integral Equation of Second Kind with Separable Kernels, Solution of Volterra Integral Equation of Second Kind, Iterated Kernels and Resolvent Kernel, Solution of Fredholm Integral Equations Using Successive Substitution, Iterated Kernels and Resolvent Kernel, Solution of Integral Equations of Convolution Type
5.	**Singular Integral Equations and Hilbert-Schmidt Theorem** Integral Equations with Symmetric Kernels, Singular and Non-Linear Integral Equation, Properties of Eigen Values and Eigen Functions, Hilbert-Schmidt Theorem, Strum-Liouville Problem

Textbooks:

1. Calculus of Variations, I. M. Gelfand and S. V. Fomin, Prentice Hall. Inc., 1963.
2. Calculus of Variations with Applications, A. S. Gupta, Prentice Hall. Inc., 1996.

References:

1. Linear Integral Equations, W. V. Lovitt, Dover Publication Inc., New York, 2005.
2. Integral Equations, S. Swarup and S. R. Singh, Krishna's Educational Publisher, 2019.
3. Integral Equations and their Applications, M. Rahman, WIT Press, Boston, 2007.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://en.wikipedia.org/wiki/Integral_equation
2. http://nptel.ac.in/courses/111104025/
3. http://mathworld.wolfram.com/IntegralEquation.html

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**III**
COURSE TITLE	**FINANCIAL MATHEMATICS**
COURSE CODE	**02MA2503**
COURSE CREDITS	**5**

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

1. Understand the mathematical foundations of quantitative Finance.
2. Construct, evaluate and analyze models for investments and securities.
3. Design, build, investigate and evaluate forward contract using arbitrage-free pricing methods.
4. Solve problems using a range of formats and approaches in basic science.
5. Apply scientific models and tools effectively

Pre-requisite of course: -

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Fundamentals of the Financial Markets** Fundamentals of Financial Market, Meaning of Notions: Asset, Portfolio, Derivatives, Classifications of Derivatives in brief: Forward, Future, Options, European and American Options, Stock, Bonds, Shares and Indices, Types of traders: Hedgers, Speculators, Arbitrageurs, Uses of Derivatives
2.	**Asset Pricing Model** Binomial Asset Pricing Model under no Arbitrage Condition, Single Period Model, Single Period Model, Risk Neutral Probabilities, Martingales in the Discrete Frame Work, Risk Neutral Valuation of European and American Options under no Arbitrage Condition in the Binomial Framework

3.	**Black - Scholes Formula** Random Walk and Brownian Motion, Geometric Brownian Motion, Black-Scholes Formula, Properties of Black Scholes Options, Estimation of Sigma, Pricing American Put Option and European Call Option
4.	**Portfolio Management** Risk, Risk and Expected Return on a Portfolio, Capital Asset Pricing Model: Capital Market Line, Beta Factor, Security Market Line
5.	**Arbitrage** Arbitrage Theorem, Multi-Period Binomial Model, Hedging: Delta Hedging, Greek Parameters, Hedging Business Risk, Value at Risk, Speculating with Derivatives

Textbooks:

1. The Mathematics of Financial Derivatives, P. Wilmott, S. Howison and J. Dewynne, Cambridge University Press, 1995.
2. An Elementary Introduction to Mathematical Finance, Sheldon M. Ross, Cambridge University Press, 2003.

References:

1. Options, Futures and Other Derivatives, John C. Hull, Prentice Hall, 2010.
2. Financial Derivatives: Theory, Concepts and Problems, S. L. Gupta, Prentice Hall, 2005.
3. An Introduction to Financial Mathematics, Kevin Hastings, Chapman and Hall, CRC Press, 2015.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.

3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://en.wikipedia.org/wiki/Mathematical_finance
2. https://plus.maths.org/content/what-financial-mathematics
3. http://www.sheir.org/financial-mathematics-notes.html
4. http://www.imar.ro/~purice/Inst/2012/imarLectureOne.pdf

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**III**
COURSE TITLE	**LINEAR ALGEBRA**
COURSE CODE	**02MA2504**
COURSE CREDITS	**5**

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

1. Understand the properties exhibited by Vector Spaces and their relationship using Linear Transformations.
2. Analyse the properties that are exhibited by Linear Transformation and their relationship with Matrices.
3. Apply the theorems on Vector Spaces and Linear Transformations to draw valid conclusions.
4. Solve linear systems of equations for vector spaces using linear transformations and converting them into matrix form to classify into various types.
5. Create an abstract vector space that would satisfy the generalized properties of Linear Transformation and Matrix Theory associated with Vector Spaces.

Pre-requisite of course: -

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	**Discussion Forum**		**CSE**	**ESE**	**ETE**	**Total Marks**
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Vector Spaces** Vector Space, Subspace of a Vector Space, Homomorphism, Isomorphism, Quotient Space, First Isomorphism Theorem, Internal Direct Sum, External Direct Sum, Linear Independence and Span, Basis of a Vector Space, Vector Space of Linear Transformations, Linear Functional, Dual Space, Second Dual, Annihilator
2.	**Linear Transformations**

	The Algebra of Linear Transformations, Minimal Polynomial, Regular and Singular Linear Transformations, Range and Rank of a Linear Transformation, Characteristic Roots, Characteristic Vectors
3.	**Canonical Forms** Similar Transformations, Invariant of a Transformation, Canonical Forms of a Nilpotent Linear Transformation, Various Canonical Forms: Triangular Form, Decomposition of Finite- Dimensional Vector Space: Jordan Form, Rational Canonical Form
4.	**Properties of Linear Transformations** Trace and Transpose of a Matrix/Transformation, Determinants, Cramer's Rule, Cayley's Hamilton theorem, Hermitian, Unitary and Normal transformations
5.	**Bilinear Forms** Real Quadratic Forms, Sylvester's Law of Inertia, Bilinear Forms, Symmetric and Skew-Symmetric Forms of Bilinear Forms, Group Preserving Bilinear Forms

Textbooks:

1. Topics in Algebra, I.N. Herstein, Wiley Eastern Ltd., 2006.
2. Linear Algebra, K. Hoffman and R. Kunze, Pearson Education, 2007.

References:

1. Advanced Linear Algebra, Steven Roman, Springer, 2007.
2. Linear Algebra: A Geometrical Approach, S. Kumaresan, Prentice Hall of India, 2000.
3. Linear Algebra, S. Lipschutz and M L Lipson, Schaum's Outlines, 2009.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://www.athabascau.ca/courses/math/270/unit07.htm
2. http://nptel.ac.in/course/111106051/
3. https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/
4. http://mathworld.wolfram.com/VectorSpace.html

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**III**
COURSE TITLE	**CLASSICAL MECHANICS AND RELATIVITY**
COURSE CODE	**02MA1506**
COURSE CREDITS	**5**

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

1. Describe different motion using Lagrange's and Hamilton's equation.
2. Find kinetic energy and potential energy for the moving particles.
3. Explain the kinematics of rigid body
4. Find equation of motion for small oscillations.
5. Understand the importance of the theory of relativity.

Pre-requisite of course: Vector calculus, differential equations, differential and integral calculus

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Lagrange's Equation** Constraints and their Types, Generalized Coordinates, degrees of Freedom, Generalized Momentum, Principal of Virtual Work, D'Alembert's Principle and Lagrange's Equation of Motion, Simple Applications of Lagrangian Formulation, Hamilton's Principle, Derivation of Lagrange's Equation from Hamilton's Principle., Extending Hamilton's Principle to Systems with Constraints, Conservation Theorems
2.	**Rigid Body Motion** Independent and Generalized Coordinates of a Rigid Body, Eulerian Angles, Components of Angular Velocity Along Body Set of Axes, Rate of Change of a

	Vector, Coriolis Force, Eulers Equation of Motion for a Rigid Body, Motion of Heavy Symmetrical Top
3.	**Hamilton's Equation of Motion** Legendre Transformation and the Hamilton Equations of Motion, Derivation of Hamilton's Equation of Motions using Lagrange's Equation, Routh Procedure, Derivation of Hamilton's equation from Hamilton's Variation Principle, Principle of Least Action, Canonical Coordinates and Transformation, Hamilton's Equation of Motion in Poisson's Bracket
4.	**Oscillations** Stable Equilibrium and Small Oscillations, Matrix Formulation, Frequencies of Free Vibration and Normal Coordinates, Normal Modes, Damped and Forced Vibration
5.	**Special Theory of Relativity** Basic Postulates of the Special Theory, Lorentz Transformation, Vectors and the Metric Tensor, 1-Forms and Tensors, Forces in the Special Theory: Electromagnetism, Relativistic Kinematics of Collisions and Many Particle Systems, Relativistic Angular Momentum, The Lagrangian Formulation of Relativistic Mechanics, Covariant Lagrangian Formulation

Textbooks:

1. Classical Mechanics, Herbert Goldstein, Charles P. Poole, John Safko, Pearson, 2011.
2. Classical Mechanics, C. R. Monda, Prentice Hall of India Pvt. Ltd., 2008.

References:

1. Classical Mechanics, R. Dougles Gregory, Cambridge University Press, 2006.
2. Classical Mechanics, Tom W. B. Kibble, Frank H. Berkshire, Imperial College Press, 2004.
3. An Introduction to Special Theory of Relativity, Robert Katz, Commission of College Physics, 2008.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process.

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory

Supplementary Resources:

1. http://www.nptelvideos.in/2012/12/special-topics-in-classical-mechanics.html
2. https://www.digimat.in/nptel/courses/video/115105098/L01.html
3. https://www.coursera.org/learn/einstein-relativity

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**III**
COURSE TITLE	**MATHEMATICAL STATISTICS**
COURSE CODE	**02MA1507**
COURSE CREDITS	**5**

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

1. Understand the mathematical basis of probability and its applications in various fields of life.
2. Adapt the knowledge of various theoretical distributions and their applications.
3. Evaluate correlation, regression and the linear regression models with the correlated data.
4. Apply Chi square test in different types of situations and understand the concept of $F-$ test and Analysis of Variance.
5. Apply statistical techniques for quality control.

Pre-requisite of course: Elementary Statistics

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Concepts of Probability** Introduction, Addition Theorem of Probability, Multiplication Theory of Probability, Binomial and Multinomial Theorem, Probability: Axiomatic Approach, Conditional Probability, Bayes Theorem, Variate or a Random Variable, Expectation of a Variate, Theorem of Expectation of Sum and Product
2.	**Theoretical Distributions** Theoretical Distributions, Binomial Distribution, Poisson Distribution, Multinomial Distribution, Hyper-geometric Distribution, Normal Distribution, Properties of Normal Distribution, Probable Error, Fitting a Normal Distribution, Central Limit Theorem
3.	**Bivariate Distribution, Correlation and Regression**

	Karl Pearson Coefficient of Correlation, Spearman Rank Correlation, Computation of Correlation Coefficient, Multiple and Partial Correlation, Curve of Regression and Regression Equation, Linear Regression, Lines of Regression, Derivation of Lines of Regression, Comparison of Correlation and Regression Analysis, Properties of Regression Coefficients, Multiple Linear Regression
4.	**Statistical Inference and ANOVA** Point and Interval Estimation, Interval Estimation of parameters, Interval Estimation of a Population Mean, Proportion, Standard Deviation, Test of Significance, Steps in Testing of Statistical Hypothesis, Students t-Distribution, Chi-square Test, Analysis of Variance, One -Way and Two - Way Classification
5.	**Statistical Quality Control** Introduction, Control Chart, Objectives of Control Charts, Construction of Control Charts (X – Bar, R – Bar) for Variables, Control Charts (P Chart, np Chart, C Chart, u Chart) for Attributes, Advantages of Statistical Quality Control, Reasons for Variations in the Quality of a Product, Techniques of Statistical Quality Control

Textbooks:

1. Fundamentals of Statistics, A. M. Goon, M. K. Gupta and B. Dasgu, The World Press, Kolkata, 2002.
2. Statistical Methods, S. P. Gupta, Sultan Chand and Sons,, 2011.

References:

1. Fundamentals of Mathematical Statistics, S. C. Gupta, V. K. Kapoor, Sultan Chand & Co. Ltd, 2002.
2. Mathematical Statistics, J. N. Kapoor & H. C. Saxena. Chand & Co. Ltd, New Delhi., 2018.
3. Computer Based Numerical and Statistical Techniques, M. Goyal, Infinity Science Press LLC, 2007.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process.

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://www.coursera.org/courses?query=statistical%20analysis
2. https://www.edx.org/learn/statistics

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**IV**
COURSE TITLE	**FUNCTIONAL ANALYSIS**
COURSE CODE	**02MA2551**
COURSE CREDITS	**5**

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

1. Understand the fundamental concepts related to Normed spaces/Banach spaces/Inner Product spaces/Hilbert spaces.
2. Apply the theorems and results on relevant spaces to solve problems in O.D.E., P.D.E., Numerical Analysis, Calculus of Variations, etc.
3. Analyse the properties of Normed space/ Inner Product space and investigate new results associated with them.
4. Prove the results that are associated with fundamental theorems of Normed spaces/Inner Product spaces.
5. Create and study new spaces that would satisfy the fundamental results of Normed Space/Inner product space and there by proposing alternative solutions.

Pre-requisite of course: Students should be familiar with concepts of metric spaces

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	**Discussion Forum**		**CSE**	**ESE**	**ETE**	**Total Marks**
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Metric Spaces** Definition of Metric Space, Examples of Metric Space, Definition of Convergence of Sequence, Cauchy sequence and Completeness of Metric Space, Definition of Isometric Mapping and Isometric Spaces.
2.	**Banach Spaces**

	Definition of Vector Space, Examples of Vector Space, Definition of Normed Space and Banach Space, Properties of Normed Space, Finite Dimensional Normed Space and their Properties, Compactness and Further Properties of Finite Dimensional Normed Space, Linear Operators and their Fundamental Properties, Bounded and Continuous Linear Operators, Linear Functional and Canonical Mapping, Linear Operators and Functionals on Finite Dimensional Spaces, Normed Spaces of Operators, Dual Space and Examples
3.	**Hilbert Spaces** Definition of Inner Product Space and Hilbert Space, Examples of Inner Product Spaces, Properties of Inner Product Spaces, Orthogonal Complements and Direct sums, Orthonormal Sets, Orthonormal Sequences and Bessel's Inequality, Series Related to Orthonormal Sequences and Orthonormal Sets, Total Orthonormal Sets and Sequences
4.	**Properties of Hilbert Spaces** Riesz theorem (for Functionals on Hilbert Spaces), Definition of Sesquilinear Functional, Riesz Representation Theorem (for Sesquilinear Functional), Hilbert Adjoint Operator and its Properties, Self-Adjoint, Unitary and Normal Operators on Hilbert Spaces and their Properties
5.	**Fundamental Theorems for Normed and Banach Spaces** Zorn's Lemma, Definition of Sublinear Functional, Hahn-Banach Theorem for Real Vector Spaces, Generalized Hahn-Banach Theorem, Hahn-Banach Theorem for Normed Spaces, Adjoint Operator, Reflexive Space, Category Theorem and Uniform Boundedness Theorem, Strong and Weak Convergence, Convergence of Sequences of Operators and Functionals, Open Mapping Theorem, Closed Graph Theorem, Banach Fixed Point Theorem (Contraction Theorem)

References:

1. Introductory Functional Analysis with its Applications, Erwin Kreyszig, John Wiley and Sons, 2007.
2. Introduction to Topology and Modern Analysis, G. F. Simmons, McGraw Hill Book Co., 2004.
3. Functional Analysis, B. V. Limaye, New Age International Ltd, 1996.
4. Functional Analysis an Introduction, Ronald Larsen & Marcel Dekker, 1973.
5. A Course in Functional Analysis, J. B. Conway, Springer-Verlag, 1990.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. http://nptel.ac.in/syllabus/111105037/
2. https://en.wikipedia.org/wiki/Normed_vector_Space
3. http://mathworld.wolfram.com/topics/FunctionalAnalysis.html
4. http://personal.lse.ac.uk/sasane/ma412.pdf

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**IV**
COURSE TITLE	**MATHEMATICAL MODELING AND SIMULATION**
COURSE CODE	**02MA1556**
COURSE CREDITS	**5**

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

1. Understand the techniques and the characteristics of mathematical models.
2. Analyse real world situations and convert in to mathematical models.
3. Solve real world problems using mathematical models.
4. Apply the theory of graphs, differential equations and difference equations in mathematical models
5. Understand simulation modelling and compare with analytic methods.

Pre-requisite of course: - Ordinary differential equations, Partial differential equations, Numerical analysis

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Introduction to Mathematical Modelling** Mathematical Models, Simple Situation Requiring Mathematical Models, Techniques, Classi&#x0Ccation, Characteristics and Limitations of Mathematical Modelling, Mathematical Modelling through Geometry, Algebra, Trigonometry, Calculus, Mathematical Modelling through Graphs: Directed Graph, Signed Graphs, Weighted Graphs, Unoriented Graphs
2.	**Mathematical Modelling through Differential Equations**

	Mathematical Modelling through ODE: Linear Growth and Decay Models, Non-linear Growth and Decay Models, Mathematical Modelling in Dynamics through ODE of First Order, Mathematical Modelling through Systems of ODE of First Order in Epidemics, Economics and Dynamics, Mathematical Modelling through ODE of Second Order and Linear Differential Equations of Second Order
3.	**Mathematical Modelling through Difference Equations** Basic Theory of Linear Difference Equations with Constant Coefficients, Mathematical Modelling through Difference Equations in Economics and Finance, Mathematical Modelling through Difference Equation in Population Dynamics and Genetics, Mathematical Modelling through Difference Equation in Probability Theory
4.	**Simulation** Introduction to Simulation and their types, Simulation Methodology, Random Number Generation, Monte-Carlo Simulation, Simulation of Continuous System, Simulation of Water Reservoir System, Simulation of a Servo System, Simulation of an Auto-Pilot, Distributed Lag model, Cobweb Model
5.	**Simulation of Different Problems** Simulation of PERT Networks, Critical Path Computation, Un-certainties in Activity Duration, Resource Allocation and Consideration, Simulation of Inventory Problem, Simulation of Queuing System, Simulation Languages, Role of Computers in Simulation

Textbooks:

1. Simulation Modelling and Analysis, Averill M. Law, W. David Kelton, McGraw Hill, Inc., 1991.

References:

1. Mathematical Modelling, J. N. Kapur, Wiley Eastern Ltd., 1998.
2. An Introduction to Mathematical Modelling, Edward A. Bender, Dover Publications, 2012.
3. Mathematical Modelling: Models, Analysis and Applications, Sandip Banerjee, CRC Press, 2014.
4. An Introduction to Difference Equations, Saber Elaydi, Springer Publication, 2005.
5. System Simulation, Geoffrey Gordon, PHI, 2007.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process.

Distribution of Theory for course delivery and evaluation					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking**
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. https://www.youtube.com/playlist?list=PLLy_2iUCG87DcqOcslyw2WB8XpSFUE0zF
2. https://www.youtube.com/watch?v=zbwyMigMFtQ
3. https://www.youtube.com/watch?v=KJNo-IgSXoM
4. https://www.youtube.com/watch?v=Ut1-WbidmIc
5. https://www.youtube.com/playlist?list=PLSGws_74K01-4rcWuB5BEATHSsOrBd1ye

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**IV**
COURSE TITLE	**SPECIAL FUNCTIONS AND INTEGRAL TRANSFORMS**
COURSE CODE	**02MA1557**
COURSE CREDITS	**5**

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

1. Understanding the concepts of infinite product, beta function and Gamma function
2. Exploring different properties of Beta function, Gamma function and hypergeometric functions.
3. Analysing Bessel's function and generating functions.
4. Analyse and apply the concepts of Hankel, Mellin and Z-transform to solve differential equations.
5. Perform different operations with orthogonal polynomials, Legendre's polynomial and Laguerre polynomial with their differential equations, corresponding recurrence relations and properties.

Pre-requisite of course: - Real Analysis, Complex Analysis, Differential Equations

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	**Discussion Forum**		**CSE**	**ESE**	**ETE**	**Total Marks**
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Infinite Product and Beta Gamma Function** Overview of an infinite Product, Introduction to Gamma Function, Euler Product, Euler's Integral, Concepts of Beta Function and Factorial Functions, Relation Between Gamma Function, Beta Function and Factorial Function
2.	**The Hypergeometric Functions**

	Introduction, A Simple Integral Form, Hypergeometric Function as a Function of Parameters, Evaluation of Hypergeometric Functions, The Contiguous Function Relations, Elementary Series Manipulation, Simple Transformations
3.	**Bessel's Function and Generating Functions** Bessel's Differential Equation, Recurrence Relation, Bessel's Integral, The Generating Function Concepts, Various Forms of Generating Function
4.	**Legendre's Polynomials and Laguerre Polynomials** Legendre's and Laguerre Differential Equations, Generating Functions, Recurrence Relations and Orthogonal Properties, Rodrigues Formula
5.	**Hankel Transforms, Mellin Transform and Z-transform with their Applications** Hankel Transform, Operational Properties of Hankel Transform, Introduction to Mellin Transform, Operational Properties of Mellin Transform, Transforms, Introduction to Z-Transform, Basic Operational Properties of Z-Transform, Inverse Z-Transform, Applications of Hankel, Mellin and Z-Transforms

References:

1. Special Functions, E. D. Rainville, The Macmillan Company, 1960.
2. Special Functions, Z. X. Wang and D. R. Guo, World Scientific Publishing Co., 1989.
3. Integral Transforms and their Applications, L. Debnath, CRC Press, New York-London-Tokyo, 1995.
4. Applied Integral Transforms, M. Y. Antimirov, A. A. Kolyshkin, R. Valliancourt, CRM Monograph Series, American Mathematical Society, 2007.
5. The Transforms and Applications Handbook, A. D. Poularikas, CRC Press, 1996.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. http://mathworld.wolfram.com/OrthogonalPolynomials.html
2. https://en.wikipedia.org/wiki/Laguerre_polynomials
3. https://www.youtube.com/watch?v=fnErOqHoPtQ
4. http://nptel.ac.in/courses/106106097/pdf/Lecture10_ZTransForm.pdf
5. https://en.wikibooks.org/wiki/Digital_Signal_Processing/Z_Transform
6. https://swayam.gov.in/nd1_noc20_ma12/preview

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**IV**
COURSE TITLE	**IMAGE PROCESSING AND FUZZY LOGIC USING MATLAB**
COURSE CODE	**02MA2553**
COURSE CREDITS	**5**

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

1. Understand the mathematical principles that are widely used in digital image processing.
2. Understand the mathematical foundations for digital image compression, image segmentation, image morphology, and image enhancement.
3. Use MATLAB software for various digital image processing applications.
4. Distinguish between the crisp set and fuzzy set concepts.
5. Demonstrate research skill associated with the domain of image processing.

Pre-requisite of course: ---

No of Interactive Sessions		**Credits**	**Examination Scheme**			
Interactive Live Lecture/ Webinar	**Discussion Forum**		**CSE**	**ESE**	**ETE**	**Total Marks**
13	32	5	30	40	30	100

Contents:

Unit	Topics
1.	**Digital Image Fundamentals** Introduction, Digital Image and Analog Image, Steps of Digital Image Processing Systems, Elements of Visual Perception, Connectivity and Relations between Pixels, Simple Operations: Arithmetic operations, Logical and Geometric Operations, Mathematical Preliminaries: 2D Convolution, Correlation
2.	**Image Enhancement and Color Image Processing**

	Image Enhancement, Histogram Equalization Technique, Point Processing, Spatial Filtering in Space and Frequency, Nonlinear Filtering use of Di&#x0B;erent Mask, Color Image Processing: Color Fundamentals, Color Models, Basis of Full Color Image Processing,
3.	**Image Compression and Segmentation** Image Compression: Introduction, Redundancy (Coding, Inter-Pixel, Physcho Visual), Image Compression Models: Lossless and Lossy, Run-Length Coding, Hu&#x0Bman Coding, Arithmetic Coding, Shannon Fano, Bit-Plane Coding, Loss Less Predictive Coding, Lossy Transform (DCT) Based Coding, Image Segmentation: Introduction, Edge Detection, Line Detection, Edge Linking and Boundary Detection, Segmentation using Threshold
4.	**Fuzzy Number and Logic** Introduction, Uncertainty and Information, Fuzzy Sets and Membership Functions, Chance verses Fuzziness, Classical and Fuzzy Sets, Properties of Classical and Fuzzy Sets, Fuzzy Set Operations, Mapping of Classical Sets to Functions
5.	**Fuzzy Relations and Fuzzification** Fuzzy Relations, Cardinality, Operations, Properties, Fuzzy Cartesian Product and Composition, Fuzzy Tolerance and Equivalence Relations, Forms of Composition Operation, Various Forms of Membership Functions, Fuzzification, Fuzzification to Crisp Sets and Scalars, Lambda Cuts and Fuzzy Relations

Suggested List of Experiments:

Unit	Topics
1.	Digital Image Fundamentals LAB 1
2.	Image Enhancement and Color Image Processing LAB 2
3.	Image Compression and Segmentation LAB 3
4.	Fuzzy Number and Logic LAB 4
5.	Fuzzy Relations and Fuzzification LAB 5

Practical Requirements: Student has to register with institutional Email Id in https://www.mathworks.com/products/matlab-online/limitations.html

References:

1. Digital Image Processing, R. C. Gonzalez and R. E. Woods, Prentice Hall, 2009.
2. Fundamentals of Digital Image Processing, A. K. Jain, PHI Learning, 2011.
3. Digital Image Processing and Analysis, B. Chanda & D. D. Majumdar, PHI Learning, 2013.
4. Fuzzy Set Theory and its Application, H. J. Zimmerman, Springer India Pvt. Ltd., 2006.
5. Fuzzy Logic with Engineering Applications, T. J. Ross, Wiley India Pvt. Ltd., 2011.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. http://mathforcollege.com/nm/resource.html
2. https://onlinecourses-archive.nptel.ac.in/noc17_ma14/preview
3. https://swayam.gov.in/nd1_noc19_ma21/preview
4. https://www.coursera.org/learn/intro-to-numerical-analysis
5. http://vlabs.iitb.ac.in/vlabs-dev/labs/numerical_lab/labs/explist.php

INSTITUTE	**FACULTY OF SCIENCE**
PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**IV**
COURSE TITLE	**MINOR PROJECT**
COURSE CODE	**02MA0582**
COURSE CREDITS	**5**

Objective:

1. The objective of the minor project is to provide an opportunity to the students to undertake short term training in terms of R&D, outside the classroom.

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

1. Formulate the problem into mathematical form and its analytical understanding.
2. Apply the techniques and various procedures for dealing with the research problem.
3. Communicate and demonstrate the learning through structured technical report, oral presentation, etc.
4. Develop the habit of self-learning and self-discipline.

Pre-requisite of course: The student should be an aspirant for research in mathematics

Teaching and Examination Scheme

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
0	0	5	-	-	100	100

Contents:

Unit	Topics
1.	**Practical Lab.** Study & apply the mathematical techniques/tools, for result orientated outcome.

Textbook:

1. Research Methodology, C Kothari, Gaurav Garg, New Age International publishers, 2019.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
0.00	10.00	40.00	20.00	10.00	20.00

Instructional Method:

1. The students are expected to be in constant touch with the supervisor and to follow guidelines strictly.
2. Student will present his/her work in the project review meeting in front of the evaluation committee formed by the HoD. There will be two review meetings.
3. Project Report submitted in the format prescribed as per the guidelines of the university will be evaluated by the examiner/s.
4. The report submitted by the student will undergo a similarity check. (Plagiarism policy as per university rule).
5. The final viva will be assessed by the external expert and hence student will be graded accordingly.

PROGRAM	**MASTER OF SCIENCE (MATHEMATICS) (ONLINE)**
SEMESTER	**IV**
COURSE TITLE	**TENSOR CALCULUS AND DIFFERENTIAL GEOMETRY**
COURSE CODE	**02MA0581**
COURSE CREDITS	**5**

Objective:

1. To provide the learner with the concept of tensor calculus and understanding of intrinsic properties of curves and surfaces.

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

1. Understand first and second fundamental forms of surface.
2. Find the osculating surface and the osculating curve at any point of a given curve.
3. Understand the Gaussian curvature, the mean curvature, the curvature lines, the asymptotic lines, the geodesics of a surface.
4. Calculate the curvature and torsion of a curve.
5. Use efficiently the mathematical tool of tensor calculus in the study of surfaces.

Pre-requisite of course: Elementary Calculus.

No of Interactive Sessions		Credits	Examination Scheme			
Interactive Live Lecture/ Webinar	Discussion Forum		CSE	ESE	ETE	Total Marks
13	32	5	30	70	-	100

Contents:

Unit	Topics
1.	**Tensor Algebra** Tensors, Kronecker's Delta, Contravariant vector and Tensor, Covariant vector and Tensor, Operation on Tensors, Mixed Tensor, Riemannian Metric
2.	**Christoffel symbols and covariant differentiation** Christoffel symbols, Covariant Differentiation, Gradient, Divergence, Curl

3.	**Introduction and Basics of Differential Geometry** Planar Curves, Space Curves, Parameterization of the Curves, First and Second Curvatures of the Curve, Signed Curvature, Serret-Frenet Equations, Fundamental Theorem of Space Curves, Isoperimetric Inequality
4.	**Surfaces** Introduction to Surfaces, Smooth Surfaces, Tangents of the Surface, Normal and Unit Normal, First Fundamental Form, Conformal Mappings of Surfaces, Surface Area, Second Fundamental Form, Gauss Mapping, Gauss and Mean Curvature, Meuniers Theorem & Euler's Theorem
5.	**Vector Field** Gauss Equations, Geodesics for the Curves, Characterization of Geodesics on Surfaces like Sphere, Cylinder & Plane, Surface of Revolution, Mainardi-Codazzi Equations

Textbook/s:

1. Differential Geometry, D. Somasundaram, Alpha Science Publication, 2005.

References:

1. Textbook of Tensor Calculus and Differential Geometry, Prasun Kumar Nayak, PHI learning, 2012.
2. Tensor Analysis, L. P. Lebedev, Michael J. ClouL. P. Lebedev, Michael J. Cloud, World Scientific, 2003.
3. Elementary Differential Geometry, Andrew Pressley, Springer Publication, 2010.
4. Differential Geometry of Curves and Surfaces, Kristopher Tapp, Springer Publication, 2016.

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking
20.00	20.00	30.00	15.00	10.00	5.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
3. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1. http://www.nptel.ac.in/course.php?disciplineId=111
2. http://www.worldscientific.com/worldscibooks/10.1142/6598
3. https://ocw.mit.edu/courses/mathematics/18-950-differential-geometry-fall-2008/
4. https://nptel.ac.in/courses/111/104/111104095/
5. https://www.youtube.com/watch?v=tKnBj7B2PSg

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