SCHEME & SYLLABUS

(Choice Based Credit System)

for

M.Sc.

in

Mathematics

(w.e.f. Session 2017-18)

Program Code: MAT301

DEPARTMENT OF MATHEMATICS

SCHOOL OF BASIC & APPLIED SCIENCES

RIMT UNIVERSITY, MANDIGOBINDGARH, PUNJAB

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SECTION 1

Vision & Mission of the University

VISION

To become one of the most preferred learning places a centre of excellence to promote and nurture future leaders who would facilitate in desired change in the society

MISSION

- To impart teaching and learning through cutting edge technologies supported by the world class infrastructure

- To empower and transform young minds into capable leaders and responsible citizens of India instilled with high ethical and moral values

- To develop human potential to its fullest extent and make them emerge as world class leaders in their professions and enthuse them towards their social responsibilities.

SECTION 2

Vision and Mission of the Department

VISION

The department aims to inculcate teaching, innovative thinking, and experiential learning voyage by disseminating theory and practice of mathematical thought to generate exceptional science graduates who make a difference to our community both locally and internationally. It aims at Continuous improvement and development of our primary stakeholder to intellectually evolve as a knowledgeable, research oriented, socially responsible, and productive citizen.

MISSION

- To provide learners to develop their hard and soft skills by providing a stimulating, intellectually challenging and engaging environment.
- To enable the students to acquire global competence through problem solving skills and exposure to latest developments.
- Providing better understanding of the domain of study, including wider scientific issues, social responsibility and ethical decision making.
- To ensure continuous interaction of the students through MOU's and collaborative research projects.

SECTION 3

About the Program

Our M. Sc. Mathematics Program is an Outcome Based Education model which is a 2 years, 4 Semesters Full time Program of 96 credit hours with a Choice Based Credit System (CBCS) and Grading Evaluation System. This program comprises of foundational courses, core courses, specialization electives courses and experimental learning. The suggestive curriculum takes the M. Sc. Mathematics program to the next level in terms of implementing Outcome Based Education and to develop mathematicians who are knowledgeable in their chosen domain, responsive to the environment and culture, unfailing to the communities, ethical in all doings and with a global outlook and approach.

These objectives shall be achieved through a very rigorous academic processes, updated and relevant curriculum, extensive industry interaction and collaborations, sports and vibrant student activities.

SECTION 4

Program Educational Objectives (PEOs), Program Outcomes (POs) and Program Specific Outcomes (PSOs)

PROGRAMME EDUCATION OBJECTIVES (PEOs)

PEO1	Apply their knowledge in modern industry or teaching, or secure acceptance in high Quality graduate programs in mathematics.
PEO2	Development in their chosen profession and progress toward an advanced degree
PEO3	The trust and respect of others as effective and ethical team members.
PEO4	Graduates will become effective collaborators and innovators, leading or participating In efforts to address social, technical and business challenges.
PEO5	Promote the culture of interdisciplinary research among all disciplines and applied mathematics

PROGRAMME OUTCOMES (POs)

PO 1	Inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions
PO 2	Equip the student with skills to analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof.
PO 3	Prepare students for pursuing research or careers in industry in mathematical sciences and allied fields.
PO 4	Imbibe effective scientific and technical communication in both oral and writing.
PO 5	Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO 1	Provide knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in other scientific and engineering domains
PSO 2	Prepare and motivate students for research studies in mathematics and related fields.
PSO 3	Understanding of the fundamental axioms in mathematics and capability of developing ideas based on them.

SECTION 5

Curriculum / Scheme with Examination Grading Scheme

INDUCTION PROGRAM

Induction Program (Mandatory)	
Duration	03 weeks
Frequency	Induction program for students to be offered right at the start of the first year
Activities	• Physical Activity • Sports, Yoga & Stress Management • Creative Arts • Universal Human Values • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

SEMESTER WISE SUMMARY OF THE PROGRAMME: M.Sc. (MATHEMATICS)

S. No.	Semester	No. of Contact Hours	Marks	Credits
1.	I	20	500	20
2.	II	25	500	25
3	III	26	500	26
4	IV	25	500	25
	Total	**96**	**2000**	**96**

COURSE CATEGORY-WISE CREDIT DISTRIBUTION

S. No.	**Category**	**Number of Credits**	**Percentage Weightage**
1	University Core		
2	University Open		
3	Program Core	91	95
4	Program Elective	5	5
5	Program Specialization		
6	MOOCs		
7	Project / Research Projects		
8	Thesis/Dissertation		
9	Training/Internships/Field Trips		
10	Professional Skills		
11	Any Other(Fundamental)		
TOTAL CREDITS		**96**	**100**

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EXAMINATION GRADING SCHEME

Marks Percentage Range	Grade	Grade Point	Qualitative Meaning
80-100	O	10	Outstanding
70-79.99	A+	9	Excellent
60-69.99	A	8	Very Good
55-59.99	B	7	Good
50-54.99	B	6	Above Average
45-49.99	C	5	Average
40-44.99	P	4	Pass
0-39.99	E	0	Fail
ABSENT	AB	0	Absent

Percentage Calculation: CGPA ×10

FIRST SEMESTER

Course		Contact Hours/Week			Credit	Contact Hrs.	Evaluation Scheme (% of Total Marks)			Exam Duration (Hours)
Course Code	Course Title	L	T	P			Internal	External	Total	
MMAT-1101	Real Analysis-I	3	1	0	4	4	40	60	100	3 Hrs
MMAT-1102	Algebra-I	3	1	0	4	4	40	60	100	3 Hrs
MMAT-1103	Operations Research I	3	1	0	4	4	40	60	100	3 Hrs
MMAT-1104	Number Theory-I	3	1	0	4	4	40	60	100	3 Hrs
MMAT-1105	Complex Analysis	3	1	0	4	4	40	60	100	3 Hrs
Total		15	5	0	20				500	

SECOND SEMESTER

Course		Contact Hours/Week			Credit	Contact Hrs.	Evaluation Scheme (% of Total Marks)			Exam Duration (Hours)
Course Code	Course Title	L	T	P			Internal	External	Total	
MMAT-1201	Real Analysis-II	4	1	0	5	5	40	60	100	3 Hrs
MMAT-1202	Algebra-II	4	1	0	5	5	40	60	100	3 Hrs
MMAT-1203	Operations Research II	4	1	0	5	5	40	60	100	3 Hrs
MMAT-1204	Number Theory-II	4	1	0	5	5	40	60	100	3 Hrs
MMAT-1205	Differential Geometry	4	1	0	5	5	40	60	100	3 Hrs

Total		20	5	0	25				500	

THIRD SEMESTER

Course		Contact Hours/Week			Credit	Contact Hrs.	Evaluation Scheme (% of Total Marks)			Exam Duration (Hours)
Course Code	Course Title	L	T	P			Internal	External	Total	
MMAT-2301/MMAT-2306	Any one subject	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2302	Field Theory	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2303	Mathematical Statistics	5	1	0	6	5	40	60	100	3 Hrs
MMAT-2304	Partial Differential Equations	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2305	Numerical Analysis	4	1	0	5	5	40	60	100	3 Hrs
Total		21	5	0	26				500	

Elective Subject

Course		Contact Hours/Week			Credit	Contact Hrs.	Evaluation Scheme (% of Total Marks)			Exam Duration (Hours)
Course Code	Course Title	L	T	P			Internal	External	Total	
MMAT-2301	Topology	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2306	Fluid Mechanics	4	1	0	5	5	40	60	100	3 Hrs

FOURTH SEMESTER

Course		Contact Hours/Week			Credit	Contact Hrs.	Evaluation Scheme (% of Total Marks)			Exam Duration (Hours)
Course Code	Course Title	L	T	P			Internal	External	Total	
MMAT-2401	Mechanics	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2402	Functional Analysis	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2403	Non-Linear Programming	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2404	Theory of Linear Operators	4	1	0	5	5	40	60	100	3 Hrs
MMAT-2405	Integral Transforms	4	1	0	5	5	40	60	100	3 Hrs
Total		20	5	0	25				500	

SECTION 6

Detailed Syllabus with Course Outcomes

SYLLABUS

SEMESTER-I

SUBJECT TITLE: Real Analysis-I
SUBJECT CODE: MMAT-1101
SEMESTER: I
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
3	1	0	4

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- This course will provide a deeper and more rigorous understanding of Calculus including defining terms and proving theorems about Metric space, sequences, series, limits, continuity, derivatives, the Riemann integrals, and sequences of functions.
- The course will develop specialized techniques in problem solving.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Finite, countable and uncountable sets. Metric spaces: Definitions and examples, open sets, closed sets, closure of set, compact sets, Perfect sets, Separated sets, Connected sets, Convergent sequences (in metric spaces). Sub-sequences, Cauchy sequences.	**15**
UNIT-II	Upper and lower limits of a sequence, Riemann's Theorem on Rearrangements of series of real and complex numbers, Limits of functions (in metric spaces), Continuous functions, Continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions.	**15**
UNIT-III	Differentiation of vector-valued functions, Definition and Existence of the Riemann-Stieltjes Integral, Properties of the Integral, Integration of vector-valued functions, Rectifiable curves, Sequences and series of functions: Problem of interchange of limit processes for sequences of Functions.	**15**
UNIT-IV	Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equi-continuous families of functions, Stone-Weierstrass theorem.	**15**

Course Outcomes:

CO1	**MMAT-1101.1**	Students are expected to be able to evaluate various problems related with real numbers, least upper bounds, and the triangle inequality.
CO2	**MMAT-1101.2**	After completing the course, students would be able to evaluate: Define functions between sets; equivalent sets; finite, countable and uncountable sets.
CO3	**MMAT-1101.3**	To apply the ratio, root, limit and limit comparison tests to check convergence and divergence of different series.

CO4	**MMAT-1101.4**	To Understand the metric space and its properties.
CO5	**MMAT-1101.5**	To determine discontinuity, continuity or uniformly continuity of metric spaces.

Recommended Books:

1. Rudin, Walter, Principles of Mathematical Analysis, Third Edition (International Student Edition) McGraw-Hill Inc. 1976.
2. Apostol, Tom, Mathematical Analysis - A Modern Approach to Advanced Calculus, Addison - Wesley Publishing Company Addison-Wesley (1964)
3. Bromwich, T.J.I.A., An Introduction to the Theory of Infinite Series. Second edition (Revised with the assistance of T. M. Mac Robert). Macmillan and Co.Ltd., New York.
4. Malik, S.C., Mathematical Analysis, Wiley Eastern, New Delhi, 1992.

SUBJECT TITLE: Algebra-I
SUBJECT CODE: MMAT-1102
SEMESTER: I
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
3	1	0	4

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- This course aims to provide a first approach to the subject of algebra, which is one of the basic pillars of modern mathematics.
- The focus of the course will be the study of certain structures called groups, rings. Abstract algebra gives to student a good mathematical maturity and enables to build mathematical thinking and skill.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Review of groups, subgroups, cosets, normal subgroups, quotient groups, homomorphisms and isomorphism theorems. Permutation groups, Even and odd permutations, Conjugacy classes of permutations.	**15**
UNIT-II	Alternating groups, Simplicity of An, n > 4., Direct products, Fundamental Theorem for finite Abelian groups, Sylow's theorems and their applications, Finite Simple groups.	**15**
UNIT-III	Survey of some finite groups, Groups of order p^2, pq (p and q primes). Normal and subnormal series, Solvable groups, Nilpotent groups, composition series, Schreier's and Jordan Holder theorem for groups.	**15**
UNIT-IV	Review of rings and homomorphism of rings, Ideals, Algebra of Ideals, Maximal and prime ideals, ideal in Quotient rings.	**15**

Course Outcomes:

CO1	**MMAT-1102.1**	To acquire knowledge of group which will help students to help further courses in mathematics like, group theory, ring theory, field theory and linear algebra
CO2	**MMAT-1102.2**	Students will be able to understand permutation groups, Even and odd permutations, Conjugacy classes of permutations.
CO3	**MMAT-1102.3**	To understand fundamental Theorem for finite Abelian groups, Sylow's theorems and their applications.
CO4	**MMAT-1102.4**	To learn skills for understanding groups of different order
CO5	**MMAT-1102.5**	After completing the course, students would be able to understand applications not only in higher mathematics but also in other science subjects like computer science.

Recommended Books:

1. Herstein I.N., Topics in Algebra (Second Edition), Wiley Eastern Limited, New Delhi, 1975.

2. Bhattacharya P.B.; Jain S.K.; and Nagpal S.R., Basic Abstract Algebra, Cambridge University Press, New Delhi, 2 edition (November 25, 1994).

3.Surjeet Singh and Qazi Zameeruddin, Modern Algebra, 8/e, Vikas Publishing House, New Delhi .

4. Gallian J.A, Contemporary Abstract Algebra, Narosa Publishing House, New Delhi 1999.

5. Serge, Lang: Modern Algebra , Springer Holder, 2002.

SUBJECT TITLE: Operations Research I
SUBJECT CODE: MMAT-1103
SEMESTER: I
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
3	1	0	4

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- The central objective of operations research is optimization, i.e., "to do things best under the given circumstances."
- The goal of operations research is to arrive at optimal or near-optimal solutions to complex problems involving some form of decision making and to provide scientific approach to problem solving in various field.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Introduction to operation research; Meaning and Definitions of OR, Significant features of OR, Typical applications of OR, Scientific methods of OR, Operation research and decision making, scope of OR, Model in OR, Development of OR India, Role of Computer in OR, Limitations of OR. Linear Programming Problems: Formulation and graphical solution, Mathematical formulation of LPP, Graphical solution of LPP.	**15**
UNIT-II	Introduction; General formulation of LPP, Some definitions, reduction of feasible solution, basic feasible solutions, procedure of simplex method, multiple optima(Alternative optimal solution, Artificial variable techniques for finding the first basic feasible solutions, tie for entering basic variables (key column), unrestricted variables, infeasible solution, some special cases of LPP, Advantages of linear programming methods, limitations of LPP'	**15**
UNIT-III	Transportation Problems: Introduction, Definition of transportation models NWCR, Least Count Method or matrix minima method, Vogel's approximation (VAM) or Penalty Method-procedural steps, Degeneracy in TP, Test of Optimality, Stepping Stone Method, the modified distribution method (MODI) method or the U-V method, unbalanced supply and demand, profit maximization problems. Assignment Problems: Introduction, Theorem-I, Thoerem-2, Comparison with transportation model, Formulation of models, Non-Square matrix, restriction on assignments and non-square matrix, typical assignment problems.	**15**
UNIT-IV	Duality in linear programming:- Introduction, duality theorem, other theorems, properties of primal and dual optimal solution, Rules-Duality and simplex method, Linear Programming with un – restricted variables, solution of system of simultaneous linear equation by simplex method, utility of dual.	**15**

Course Outcomes:

CO1	**MMAT-1103.1**	To understand meaning, definitions and applications of OR.
CO2	**MMAT-1103.2**	Students will be able to formulate and give graphical solution of LPP.
CO3	**MMAT-1103.3**	To acquire knowledge of finding solution of transportation and assignment problem.
CO4	**MMAT-1103.4**	To learn skills for understanding role of duality in linear programming Problem.
CO5	**MMAT-1103.5**	After completing the course, students would be able to understand applications of OR in solving problems in other fields.

Recommended Books:

1. Operations research, Kanti swaroop, S. Chand publications, 2005.
2. Operations research, A.TAHA Pearson; 9 edition (September 8, 2010).
3. Operations research, S. D. Sharma, Himanshu Sharma, Tripti Shrama Kedarnath and RamNath & Co.

SUBJECT TITLE: Number Theory-I
SUBJECT CODE: MMAT-1104
SEMESTER: I
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
3	1	0	4

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- The objectives of this course are to expose students to this beautiful theory, to understand Fundamental Theorem of arithmetic.
- To allow students to experience mathematics as a creative, empirical science.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Divisibility, Greatest common divisor, Prime numbers, Euclidean Algorithm, The Diophantine equation ax + by = c, Fundamental Theorem of arithmetic Arithmetical functions: Mobius function, Euler's totient function, Mangoldt function, Liouville's function.	**15**
UNIT-II	The divisor functions, Relation connecting φ and μ, product formula for φ(n), Dirichlet's product of arithmetical functions, Dirichlet's inverses and Mobius inversion formula, Multiplicative functions, Dirichlet's multiplication, The inverse of a completely multiplicative function, Generalized convolutions.	**15**
UNIT-III	Congruences: Definition and basic properties of congurences, residue classes and complete residue system, linear congurences, simultaneous linear congurences, Chinese remainder theorem,	**15**
UNIT-IV	Fermat's little theorem, Wilson's theorem, Euler's theorem, and Fermat numbers, Euler's Criterion, Legendre symbol and its properties, Quadratic reciprocity.	**15**

Course Outcomes:

CO1	**MMAT-1104.1**	To define interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization
CO2	**MMAT-1104.2**	Students will be able to apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.
CO3	**MMAT-1104.3**	To acquire knowledge of formulation and to prove conjectures about numeric patterns
CO4	**MMAT-1104.4**	To learn skills to produce rigorous arguments (proofs) centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.
CO5	**MMAT-1104.5**	After completing the course, students would be able to understand different theorems

Recommended Books:

1. David, M. Burton, Elementary Number Theory, (UBS Publishers) Indian Edition 2017.

2. Niven, Zuckerman & Montgomery, Introduction to Theory of Numbers, (John Wiley & Sons) ,5th Edition, 1991.

3. Davenpart H., Higher Arithmetic (Camb. Univ. Press), 2008.

4. Hardy & Wright, Number Theory (Oxford Univ. Press), 4th Edition, 2012.

5. Dence, J. B. & Dence T. P., Elements of the Theory of Numbers (Academic Press), 1999.

SUBJECT TITLE: Complex Analysis
SUBJECT CODE: MMAT-1105
SEMESTER: I
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
3	1	0	4

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- This course is aimed to provide an introduction to the theories for functions of a complex variable with particular emphasis on Cauchy's Theorem and the calculus of residues.
- To introduce concepts of analyticity, Cauchy-Riemann relations and harmonic functions.
- To help student to visualize multi-valued complex functions.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Limits, Limits involving the point at infinity, continuity, Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings, Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.	**15**
UNIT-II	Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions. Definite integrals of functions, Contours, Contour integrals and its examples, upper bounds for modulli of contour integrals.	**15**
UNIT-III	Cauchy Integral theorem, Cauchy integral formula, An extension of Cauchy integral formula, consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples, Laurent series and its examples.	**15**
UNIT-IV	Absolute and uniform convergence of power series, uniqueness of series representations of power series. Isolated singular points, residues, Cauchy's residue theorem, residue at infinity, Types of isolated singular points, residues at poles and its examples, definite integrals involving sines and cosines.	**15**

Course Outcomes:

CO1	**MMAT-1105.1**	To handle certain integrals not evaluated earlier and will know a technique for counting the zeros of polynomials.
CO2	**MMAT-1105.2**	Students will be able to apply concept of complex analysis in other problems.
CO3	**MMAT-1105.3**	To acquire knowledge of analytic functions and its applications.
CO4	**MMAT-1105.4**	To learn skills to find solution of many problems related with complex analysis using theorems.
CO5	**MMAT-1105.5**	After completing the course, students would be able to understand use of this course in many other advance analysis courses.

Recommended Books

1. Kasana, H. S.:complex variables theory and applications PHI Learning Pvt. Ltd., 2005 .
2. Ahlfors, D. V.: Complex analysis , Mc.Graw Hill, 3rd. edition, 1979.
3. Conway, J.B.: Functions of one complex variable, Edition1, 1973.
4. Copson, E. T.: Theory of functions of complex variables, Oxford Clarendon press 2011.
5. B. S. Tyagi, : Functions of a complex variable , Kedar Nath Ram Nath, 1981.

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SYLLABUS

SEMESTER-II

SUBJECT TITLE: Real Analysis-II
SUBJECT CODE: MMAT-1201
SEMESTER: II
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- This course aims to provide special knowledge necessary for basic concepts in Real Analysis.
- To enable students to learn basic concepts about functions of bounded variation, grasp basic concepts about the differentiation of monotone functions, measurable Functions, Lebesgue Integral.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Functions of several variables: Linear Transformation, Differentiation of a vector-valued function of several variables, Inverse function theorem, Implicit function theorem, Differentiation of an integral.	**15**
UNIT-II	Differentiation and Integration: Differentiation of monotone functions, Differentiation of an integral, convex functions, Differentiation under integration Measure Sets: Outer measure, Lebesgue Measure, Properties of Measurable Sets, Non- measurable Set.	**20**
UNIT-III	Measurable Functions: Definition and Properties, Simple Functions, Little wood's three principles Lebesgue Integral: Lebesgue Integral of a bounded function over a set of finite measure. Integral of a non-negative function.	**20**
UNIT-IV	General Lebesgue Integral, Convergence in measure. , Fatou's Lemma , Principle of bounded variation , Lebesgue convergence Theorem , Monotone convergence Theorem , Bounded Convergence Theorem.	**20**

Course Outcomes:

CO1	**MMAT-1201.1**	To understand differentiation of a vector-valued function of several variables.
CO2	**MMAT-1201.2**	Students will be able to understand differentiation of an integral.

CO3	**MMAT-1201.3**	To acquire knowledge of comprehend rigorous arguments developing the theory underpinning real analysis.
CO4	**MMAT-1201.4**	To learn skills to demonstrate an understanding of limits and how they are used in sequences, series, differentiation and integration.
CO5	**MMAT-1201.5**	On successful completion of this course, students would be able to understand use general Lebesgue Integral.

Recommended Books

1. Rudin, Walter, Principles of Mathematical Analysis, McGraw-Hill Inc., 3rd Edition, 1976.
2. Royden, H.L., Real Analysis, Macmillan and Co. Ltd. New York , 3rd edition (March 1988).
3. Apostol, Tom, Mathematical Analysis - A Modern Approach to Advanced Calculus, Addison - Wesley Publishing Company. (Indian Edition by Narosa Publishing House New Delhi also available).
4. Barra G.D. , Real Analysis , Wiely Eastern Limited, 1981.

SUBJECT TITLE: Algebra-II
SUBJECT CODE: MMAT-1202
SEMESTER: II
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective: The objectives of this course is

- To provide knowledge about different algebraic structures.
- To acquire interest in advanced concepts like Unique Factorization Domain , Principal Ideal Domain , Euclidian Domain and Modules.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Unique Factorization Domain (UFD), Principal Ideal Domain (PID), Euclidian Domain (ED) and their relationships, Polynomial rings.	**15**
UNIT-II	Ring of Gaussian Integers. Ring with chain conditions: Noetherian and Artinian Rings, Examples and Counter Examples, Hilbert Basis Theorem.	**20**
UNIT-III	Modules: Definition and Examples, Sub-module, Direct sum of sub-modules, Difference between Modules and Vector Spaces, R-Homomorphism and Quotient Module, Completely reducible or Semi-simple Modules, Free Modules	**20**
UNIT-IV	Representation and Rank of Linear Mappings, Finitely generated modules over a PID: Decomposition Theorem and Uniqueness, Application and Rational canonical form .	**20**

Course Outcomes:

CO1	**MMAT-1202.1**	To simplify or manipulate expressions involving polynomial, radical, rational, exponential or logarithmic terms using appropriate properties and rules.
CO2		Students will be able to use numeric or variable substitution while

	MMAT-1202.2	working with expressions
CO3	**MMAT-1202.3**	To acquire knowledge for determining whether two expressions, functions or equations involving polynomial, radical, rational, exponential or logarithmic terms are equivalent.
CO4	**MMAT-1202.4**	To learn skills to use appropriate strategies, properties, and rules to show they are the same.
CO5	**MMAT-1202.5**	On successful completion of this course, students would be able to find a counter example

Recommended Books

1. Herstein I.N., Topics in Algebra (Second Edition), Wiley Eastern Limited, New Delhi, 1975.

2. Surjeet Singh and Qazi Zameeruddin, Modern Algebra,8/e, Vikas Publishing House, New Delhi .

3. Bhattacharya P.B.; Jain S.K.; and Nagpal S.R., Basic Abstract Algebra, Cambridge University Press, New Delhi, 1994.

4. Gallian J.A, Contemporary Abstract Algebra, Narosa Publishing House, New Delhi, 1999.

5 Serge Lang: Modern Algebra, Springer Holder, 2002.

SUBJECT TITLE: Operations Research -II
SUBJECT CODE: MMAT-1203
SEMESTER: II
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To develop a scientific model of the system incorporating measurement of factors such as chance and risk.
- To predict and compare the outcome of alternative decisions, strategies or controls with the help of game theory , Decision Theory and Inventory Management.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Game Theory:- Introduction, Definition and explanations of some important terms, Two-Person zero sum game, Game with saddle point(mixed strategies), matrix reduction by dominance, graphical method, method of linear programming, advantages of game theory, limitation of game theory.	**15**
UNIT-II	Decision Theory:- Introduction, cost structure of a queuing problem, queuing system-customer behavior, the state of the system, notations, assumption involved in waiting line theory, some distributions, model for arrival and service time(single phase) Poisson process and exponential distribution, Kendall's notation for representing queuing model, classification of queuing models:- a) Model I – M/M/I:∞/FCFS b) Model II – M/M/I: ∞/SIRO c) Model III – Birth – Death Process d) Model IV – M/M/I:N/FCFS e) Model V – M/M/C: ∞/FCFS **f)** Model VI - ∞/FCFS Erlang Distribution	**20**
UNIT-III	Inventory Management : - Introduction, Definition, objectives of inventory control, inventory classification, necessity for maintaining inventory, types of inventory, the inventory decisions, inventory costs, other factors involved in	**20**

	inventory, deterministic inventory management, classification of inventory models.	
UNIT-IV	Deterministic inventory management: Economic Order quantity, demand production rate uniform, production rate infinite, demand rate non-uniform, production rate infinite, finite replenishment rate, demand rate uniform, production rate finite, multi-product case. Planned backlogging (demand rate uniform, production rate infinite, shortage allowed, time interval fixed, demand rate uniform, production rate finite, shortage allowed, inventory models with probabilistic demand.	**20**

Course Outcomes:

CO1	**MMAT-1203.1**	To describe administrative decision problems and identify those parameters that affects the case study of optimization.
CO2	**MMAT-1203.2**	To Select the methodology or combination of methodologies to be used to solve the optimization problems.
CO3	**MMAT-1203.3**	To acquire knowledge of Game Theory and Decision Theory.
CO4	**MMAT-1203.4**	To learn skills to use appropriate strategies for inventory management.
CO5	**MMAT-1203.5**	On successful completion of this course, students would be able to identify previous cases that constitute good practice and are related to the examined case.

Recommended Books

1. Operations research, Kanti swaroop, S. Chand publications, 2005.
2. Operations research, A.TAHA 9th Edition, 2010.
3. operations research, S. D. Sharma, Himanshu Sharma, Tripti Shrama, Kedar Nath and Ram Nath & Co.

SUBJECT TITLE: Number Theory -II
SUBJECT CODE: MMAT-1204
SEMESTER: II
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- To provide deeper knowledge of Calculus including defining terms and proving theorems.
- To acquire rigorous understanding on asymptotic equality of functions, Shapiro's Tauberian theorem, Chebyshev's functions $\psi(x)$ & $\theta(x)$.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Averages of arithmetical functions: The big oh notation, Asymptotic equality of functions, Euler's summation formula, Elementary asymptotic formulas, Average order of $d(n)$, $\varphi(n)$,$\sigma_\alpha(n)$, $\mu(n)$, $\Lambda n)$,	**15**
UNIT-II	The Partial sums of a Dirichlet's product, applications to $\mu(n)$ and $\Lambda(n)$. Another identity for the partial sums of a Dirichlet's product, Chebyshev's functions $\psi(x)$ & $\theta(x)$, Relation connecting $\theta(x)$ and $\pi(x)$, Abel's identity, equivalent forms of Prime number theorem, inequalities for $\pi(n)$ and P_n.	**20**
UNIT-III	Shapiro's Tauberian theorem, applications of Shapiro's theorem, Asymptotic formula for the partial sums $\Sigma_{p\leq x}(1/p)$. Elementary properties of groups , Construction of subgroups.	**20**
UNIT-IV	Characters of finite abelian groups, The character group, Orthogonality relations for characters, Dirichlet's characters, Dirichlet's theorem for primes of the form 4n-1 and 4n+1.	**20**

Course Outcomes:

CO1	**MMAT-1204.1**	Students will be able to express the concepts and results of Number Theory effectively.
CO2	**MMAT-1204.2**	To construct mathematical proofs of statements and find counterexamples to false statements in Number Theory
CO3	**MMAT-1204.3**	To acquire knowledge of theorems and its applications.
CO4	**MMAT-1204.4**	To learn skills to collect and use numerical data to form conjectures about the integers.
CO5	**MMAT-1204.5**	Upon successful completion of this course, students would be able to understand the logic and methods behind the major proofs in number theory.

Recommended Books

1. David, M. Burton, Elementary Number Theory, (UBS Publishers) Indian Edition 2017.

2. Niven, Zuckerman & Montgomery, Introduction to Theory of Numbers, (John Wiley & Sons) ,5th Edition, 1991.

3. Davenpart H., Higher Arithmetic (Camb. Univ. Press), 2008.

4. Hardy & Wright, Number Theory (Oxford Univ. Press), 4th Edition, 2012.

5. Dence, J. B. & Dence T. P., Elements of the Theory of Numbers (Academic Press), 1999.

SUBJECT TITLE: Differential Geometry
SUBJECT CODE: MMAT-1205
SEMESTER: II
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- To provide deep knowledge of Curves and different geometrical structures.
- To know different term and surfaces such as Tensor Analysis, Developable and skew surfaces, Gauss and Weingarten formulae, Introduction to Geodesics, Geodesics differential equation.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	**Curves in R :** A simple arc, curves and their parametric representation, arc length and natural parameter, Contact of curves, tangent, principal normal, bi normal, osculating plane, curvature and torsion, Serret -Frenet Formulae, Helics, Evolutes and Involutes of a parametric curve, spherical curves.	**20**
UNIT-II	**Tensor Analysis:** Einstein's Summation Convention, Transformation laws for vectors, Contra-variant, covariant and mixed Tensors, addition, multiplication, contraction and quotient law of tensors.	**15**
UNIT-III	Differentiation of Cartesian Tensors, metric Tensor, Christoffel symbols, Covariant differentiation of tensors, **Surfaces in R :** Implicit and Explicit forms for the equation of the surface, the two fundamental forms of a surface.	**20**

UNIT-IV	Family of surfaces, Edge of regression, Envelops, Ruled surface, Developable and skew surfaces, Gauss and Weingarten formulae, Introduction to Geodesics, Geodesics differential equation.	**20**

Course Outcomes:

CO1	**MMAT-1205.1**	Students will be able to express the concepts and results of Number Theory effectively.
CO2	**MMAT-1205.2**	To construct mathematical proofs of statements and find counterexamples to false statements in Number Theory
CO3	**MMAT-1205.3**	To acquire knowledge of theorems and its applications.
CO4	**MMAT-1205.4**	To learn skills to collect and use numerical data to form conjectures about the integers.
CO5	**MMAT-1205.5**	Upon successful completion of this course, students would be able to understand the logic and methods behind the major proofs in number theory.

Recommended Books:

1. A. Pressley, Elementary Differential Geometry, Springer, 2nd Edition, 2010.

2.Martin M. Lipschutz, Differential Geometry, McGraw-Hill, 1969.

3. U.C. De; A.A. Shaikh & J. Sengupta: Tensor Calculus, Narosa Publishing, 2018.

4. T.J.Willmore, Introduction to Differential Geometry, Courier Corporation, 2013.

5. M.R. Spiegel: Vector Analysis, 2016, Schaum's Series.

SUBJECT TITLE: Topology
SUBJECT CODE: MMAT-2301
SEMESTER: III
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To introduce different aspects of topology.
- To explore the foundations of mathematics with emphasis on set theory, Cauchy convergent sequences and on connected spaces.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Finite and Infinite sets. Denumerable and Non denumerable sets, Equivalent sets. Concept of Cardinal numbers, Schroeder Bernstein Theorem. Cardinal number of a power set – Addition of Cardinal numbers, Exponential of Cardinal numbers, Examples of Cardinal Arithmetic, Cantor's Theorem.	**20**
UNIT-II	Definition of a metric. Bolzano – Weierstrass theorem. Open and closed balls. Cauchy convergent sequences. Complete metric spaces. Continuity (definition) Contraction mapping theorem. Banach fixed point theorem, Bounded and totally bounded sets. Cantor's Intersection Theorem. Nowhere dense sets. Baire's category theorem, Isometry, Embedding of a metric space in a complete metric space.	**20**
UNIT-III	Topology: Definition and examples Open and closed sets. Neighbour hoods and Limit Points, Closure, Interior and Boundary of a set, Relative topology, Bases and sub bases, Continuity and Homeomorphism	**15**

UNIT-IV	Pasting lemma, Connected spaces: Definition and examples, connected sets in the real line, Intermediate value theorem, components and path components, local connectedness and path connectedness.	**20**

Course Outcomes:

CO1	**MMAT-2301.1**	Students will be able to express the concepts and results of Topology.
CO2	**MMAT-2301.2**	To construct mathematical proofs of statements and find counter examples in Topology.
CO3	**MMAT-2301.3**	To acquire knowledge of theorems and its applications.
CO4	**MMAT-2301.4**	To learn skills for development of pure mathematics will provide various applications in the field of sciences
CO5	**MMAT-2301.5**	Upon successful completion of this course, students would be able to understand the logic and methods with the study of set theory including Finite and Infinite sets, Denumerable and Non denumerable sets, Equivalent sets, Concept of Cardinal numbers

Recommended Books:

1. J. R. Munkres, Topology, Second Edition, Prentice Hall of India, 2nd Edition 2002.
2. W.J. Pervin : Foundations of General Topology - Academic Press, 1964.
3. G. F. Simmons : Introduction to Topology and Modern Analysis – Tata Mc Graw Hill, 2016.
4. J. Dugundji : Topology - Prentice Hall of India, 1975.
5. G J.L. Kelley, General Topology, Princeton , Van Nostrand Company Inc. 1955.

SUBJECT TITLE: Fluid Mechanics
SUBJECT CODE: MMAT-2306
SEMESTER: III
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam; 3 Hrs

Objective:

- To provide a foundation in the fundamentals of fluid mechanics.
- To formulate analytically fluid mechanics problems using Newton's Laws of motion and thermodynamics.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Equations of Fluid Mechanics : Real and continuous fluids, differentiation following the motion, equation of continuity, Stream function, Stream lines, Pressure, Euler's equation of motion. Bernoulli's theorem Steady irrotational non-viscous compressible flow. Vorticity, circulation, Kelvin's theorem on constancy of circulation, Kinetic energy.	**20**
UNIT-II	Three dimensional problems : Laplace's equation. Three dimensional sources and dipoles. Spherical obstacle in a uniform steam Moving sphere, images	**15**
UNIT-III	Application of complex variable method : Conjugate functions in plane, complex potential, incompressible flow in two dimensions, uniform stream, Source and sink, Vortex, Two dimensional dipole, Superposition, Joukowski's transformation. Milne Thomson circle theorem, Blasius theorem, Drag and lift	**20**

	Source and vortex filaments, vortex pair, rows of vortices, Karman cortex street.	
UNIT-IV	Viscous flow : Navier Stokes equations, Dissipation of energy. Diffusion of vorticity in an incompressible fluid, condition of no slip, Steady flow between two parallel infinite flat plates, steady flow through a straight circular pipe (Poiseuille Flow).	**20**

Course Outcomes:

CO1	**MMAT-2306.1**	Students will be able to understand concepts and results of stress-strain relationship in fluids.
CO2	**MMAT-2306.2**	To classify mathematical behavior of statements and also establish force balance in static systems.
CO3	**MMAT-2306.3**	To acquire knowledge of theorems and its applications.
CO4	**MMAT-2306.4**	To learn skills to apply Bernoulli principle and compute pressure drop in flow systems of different configurations.
CO5	**MMAT-2306.5**	Upon successful completion of this course, students would be able to compute power requirement in fixed bed system and determine minimum fluidization velocity in fluidized bed.

Recommended Books:

1. D. E. Rutherford : Fluid Dynamics, Edward Arnold Pub. Ltd. 1959.

2. F. Chorlton : Fluid Dynamics, (Relevant portion) 2004 by CBS Publishers & Distributors.

Instruction of Question Paper setter

The paper setter is required to set question paper in three sections A , B and C . Section A consists of 5 very short questions of 2 marks each. Section B having choice 4 out of 5 Questions of 5 marks each and section C having choice 3 out of 4 Questions of 10 marks each.

SUBJECT TITLE: Field Theory
SUBJECT CODE: MMAT-2302
SEMESTER: III
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To present foundational material for the last of the basic algebraic structures pervading contemporary pure mathematics, namely fields and modules.
- To know basic definitions and elementary results followed by applications of the theory.
- The subject concludes by returning to fields to present interesting Algebraic Extensions of fields and Galois Theory.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Algebraic Extensions of fields : Adjunction of roots , Algebraic extensions , Algebraically closed fields.	**15**
UNIT-II	Normal and Separable extensions : Splitting fields , Normal extensions , Multiple roots, Finite fields, Separable extensions	**20**
UNIT-III	Galois Theory: Automorphism groups and fixed fields , Fundamental theorem of Galois theory, Fundamental theorem of algebra ,Roots of unity and cyclotomic polynomials, Cyclic extensions	**20**

UNIT-IV	Applications of Galois theory: Polynomials solvable by radicals , Constructions by ruler and compass , Symmetric functions	**20**

Course Outcomes:

CO1	**MMAT-2302.1**	To identify and construct examples of fields, distinguish between algebraic and transcendental extensions.
CO2	**MMAT-2302.2**	To define perfect fields and characterize them using separable extensions.
CO3	**MMAT-2302.3**	To acquire knowledge for construct examples of auto-morphism group of a field and Galois extensions
CO4	**MMAT-2302.4**	To learn skills to apply Galois theory of equations to prove that a polynomial equation over a field of characteristic is solvable by radicals.
CO5	**MMAT-2302.5**	Upon successful completion of this course, students would be able to use applications of Galois theory in different fields.

Recommended Books:

1. Bhattacharya, Jain and Nagpal, Basic Abstract Algebra,Cambridge university Press, UK.(Asian edition), 1994 .
2. Nathan Jacobson , Basic Algebra I, second edition, , W. H. Freeman and company, New York, Dover Publications; Second edition (June 22, 2009).
3. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd. 1975.
4. U. M. Swamy, A. V. S. N. Murthy, Algebra: Abstract and Modern, Pearson Education, 2011.
5. John Fraleigh, A first course in Abstract Algebra Narosa publishing house, New Delhi, 2003.
6. I. T. Adamson, Introduction to Field Theory, second edition, Cambridge University Press, 2012.
7. M. Artin, Algebra, Pearsons, 2015.

SUBJECT TITLE: Mathematical Statistics
SUBJECT CODE: MMAT-2303
SEMESTER: III
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
5	1	0	6

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To provide intense foundational introduction to the fundamental concepts in Mathematics to the non- science/ mathematics/ engineering/ business student.
- Ability to provide competency in solving basic problem and word problems in logical way.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Probability: Intuitive concept of Probability, Combinatorial problems, conditional probability and independence, Bayes' theorem and its applications. Random Variables and Distributions: Discrete and Continuous random variables.	**25**
UNIT-II	Probability mass function and Probability density function, Cumulative distribution function. Expectation random variables. Properties of random variables. Moment generating function and probability generating functions.	**25**

UNIT-III	Distributions: Bernoulli distribution. Binomial distribution. Poisson distribution, Negative Binomial and Hyper geometric distributions. Uniform, Normal distribution	**20**
UNIT-IV	Normal approximation to Binomial and Poisson distributions. Beta, Gamma distributions. Testing of Hypothesis z-test, t-test, F-test, ANOVA.	**20**

Course Outcomes:

CO1	**MMAT-2303.1**	To identify and construct examples of probability with discrete and continuous random variables.
CO2	**MMAT-2303.2**	To define probability mass function and probability density function
CO3	**MMAT-2303.3**	To acquire knowledge for solving many problems with use of probability.
CO4	**MMAT-2303.4**	To learn skills to apply different distributions to solve many problems.
CO5	**MMAT-2303.5**	Upon successful completion of this course, students would be able to testing Hypothesis.

Recommended Books:

1. Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-I & Vol-II , 2017, The World Press, Kolkata.
2. Sheldon Ross : A First Course in Probability, (9th Hardcover **Edition**), **Pearson**, 2013.
3. Meyer, P.L: Introductory Probability and Statistical Applications, Addition-Wesley Pub. Co.1970.
4. Hogg, R.V. and Craig, T.: Introduction to Mathematical Statistics , Pearsons Education, 2005.

SUBJECT TITLE: Partial Differential Equations
SUBJECT CODE: MMAT-2304
SEMESTER: III
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To introduce students how to solve linear Partial Differential with different methods
- To apply method to solve some physical problems in Engineering and Biological models.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	First Order PDE: Definition of PDE, origin of first-order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE;	**20**
UNIT-II	Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution, Second Order PDE: Origin of second order PDE, linear	**20**

	second order PDE with constant coefficients, linear second order PDE with variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order.	
UNIT-III	Method of Solution: Separation of variables in a PDE; Laplace, wave and diffusion equations, Elementary solutions of Laplace equations, Applications of PDE: Wave equation, the occurrence of wave equations.	**15**
UNIT-IV	Elementary solutions of one dimensional wave equation; vibrating membranes, three dimensional problems. Diffusion equation, resolution of boundary value problems for diffusion equation, elementary solutions of diffusion equation.	**20**

Course Outcomes:

CO1	**MMAT-2304.1**	To understand definition and origin of first-order PDE.
CO2	**MMAT-2304.2**	To identify the use of ideas of using of PDE.
CO3	**MMAT-2304.3**	To acquire knowledge of different method for solving PDE.
CO4	**MMAT-2304.4**	To learn skills to solve different types of equations using PDE.
CO5	**MMAT-2304.5**	Upon successful completion of this course, students would be able to solve PDE with different methods.

Recommended Books:

1. Elements of Partial Differential Equation (3rd edition) – I. N. Sneddon, McGraw Hill Book Company, 1988.

2. Partial Differential Equations– E. T. Copson, Cambridge University Press, 1975.

3. Partial Differential Equations: An Introduction [Hardcover]Walter A. Strauss, Wiley; 2 edition (December 21, 2007).

4. Sankara Rao, Introduction to partial differential equations, PHI, 2010.

SUBJECT TITLE: Numerical Analysis
SUBJECT CODE: MMAT-2305
SEMESTER: III
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective: The objective of this course is

- To provide numerical methods of solving the non-linear equations, interpolation, differentiation and integration
- To improve the student's skills in numerical methods by using the numerical analysis software and computer facilities.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Numerical Computation and Error Analysis: Numbers and their accuracy, Floating point arithmetic, Errors in numbers, error estimation, general error formulae, error propagation in computation. Algebraic and Transcendental Equations: Bisection method, iteration method, Regula-Falsi method, secant method, Newton-Raphson method. Convergence of these methods. Solution of system of nonlinear equations, complex roots by Newton – Raphson method.	**20**
UNIT-II	System of Linear Algebraic Equations: Guass Elimination method, Gauss – Jordon method , LU factorization method , Jacobi and Gauss-Seidal methods,	**15**

	Convergence of iteration methods, Inverse of Matrices. Eigen values and Eigen vector: Rayleigh Power method.	
UNIT-III	Interpolation: Finite differences, Newton interpolation formulae, Gauss, Stirling and Bessel's formulae, Lagrange's, Newton's divided difference formulae. Numerical differentiation and integration: differentiation at tabulated and non-tabulated points, maximum and minimum values of tabulated function, Newton-Cotes formulae-Trapezoidal, Simpson's, Weddle rules of integration.	**20**
UNIT-IV	Ordinary Differential Equations: Taylor series and Picard's methods, Euler and modified Euler methods, Runge –Kutta methods, Predictor- Corrector methods: Adam-Beshforth and Miline methods. Boundary values problems: Finite difference methods.	**20**

Course Outcomes:

CO1	**MMAT-2305.1**	To explain the concepts and approximate solutions to otherwise intractable mathematical problems.
CO2	**MMAT-2305.2**	To analyze and solve problems using numerical methods.
CO3	**MMAT-2305.3**	To derive numerical methods for various mathematical operations and tasks.
CO4	**MMAT-2305.4**	To learn skills to apply numerical methods techniques to specific research problems in mathematics or other fields.
CO5	**MMAT-2305.5**	Upon successful completion of this course, students would be able to analyze and evaluate the accuracy of common numerical methods

Recommended Books:

1. B. Bradie: A friendly introduction to Numerical Analysis.Pearson Prentice Hall, 2007.

2. K. E. Atkinson, Introduction to Numerical Analysis (2nd edition), John Wiley, 1978.

3. S. D. Conte and C. De Boor, Elementary Numerical Analysis: An Algorithmic Approach (3rd edition), McGraw Hill, New York, 1981.

SUBJECT TITLE: Mechanics
SUBJECT CODE: MMAT-2401
SEMESTER: IV
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective: The primary purpose of the study of mechanics is

- To develop the capacity to predict the effects of force and motion while carrying out the creative design functions.
- Ability to visualize physical configurations in terms of real materials, actual constraints and the practical limitations which govern the behavior of machines and structures.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Vector Integration: Line integrals, Surface area and surface integrals, Volume integrals, Integral Theorems, Green's theorem, Gauss divergence theorem, Stoke's theorem .Curvilinear Coordinates, Orthogonal coordinates, Unit vectors in curvilinear systems, Arc length and volume elements	**15**
UNIT-II	The gradient, Divergence and curl , Rotation of a rigid body about a fixed axis:	**20**

	Moments and products of inertia of various bodies including hoop or cylindrical shell, circular cylinder, spherical shell Parallel and perpendicular axis theorem Motion of Rigid Bodies in Three Dimensions Rotating coordinate systems.	
UNIT-III	Velocity and acceleration in moving system: Centripetal and transverse acceleration, Dynamics of a particle in a rotating coordinate system, Planar Motion of Rigid Bodies Introduction to rigid and elastic bodies, Degrees of freedom, Translations, Rotations, instantaneous axis and center of rotation, Motion of the center of mass, Euler's theorem	**20**
UNIT-IV	General motion of rigid bodies in space: Moments and products of inertia, Inertia matrix The momental ellipsoid and equimomental systems, Principal axes and principal moments of inertia, Free rotation of a rigid body with an axis of symmetry Free rotation of a rigid body with three different principal moments Euler's Equations, The Eulerian angles	**20**

Course Outcomes:

CO1	**MMAT-2401.1**	To explain the concepts and determine the resultant of forces and moments
CO2	**MMAT-2401.2**	To understand and find solution using vector integration.
CO3	**MMAT-2401.3**	To apply laws of mechanics to determine efficiency of simple machines with consideration of friction
CO4	**MMAT-2401.4**	To learn skills to applying concept of moment and product of inertia in many problems.
CO5	**MMAT-2401.5**	Upon successful completion of this course, students would be able to Apply Newton's laws and conservation laws to elastic collisions and motion of rigid bodies.

Recommended Books:

1.G. E. Hay, Vector and Tensor Analysis (Dover Publications, Inc., 1979)

2.G. R. Fowles and G. L. Cassiday, Analytical Mechanics, (Thomson Brooks/Cole, 2005)
3. M. R. Spiegel, Theoretical Mechanics, (McGraw Hill Book Company, 1980)
4. H. Goldstein, C. P. Poole and J. L. Safko, Classical Mechanics,
(Addison-Wesley Publisihng Co., 2001)

SUBJECT TITLE: Functional Analysis
SUBJECT CODE: MMAT-2402
SEMESTER: IV
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective: The objective of this course

- To provide knowledge to the students with various advanced concept.
- To understand Banach spaces, Hilbert space and Banach Algebras.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Normed linear spaces, Banach spaces, properties of normed spaces, finite dimensional normed spaces and subspaces, linear operator, bounded and continuous linear operators, linear functional.	**15**
UNIT-II	Normed spaces of operators Equivalent norms, conjugate spaces, Reflexivity. Hahn-banach theorems for real/complex vector spaces and normed spaces, application to bounded linear functional on C [a,b].	**20**

UNIT-III	Uniform boundedness theorem, open mapping theorem, closed graph theorem, Projections on Banach spaces. . Dual spaces of lp and C [a,b], Inner product spaces, Hilbert spaces, properties of inner product spaces examples,	**20**
UNIT-IV	Orthogonality, Orthonormal sets. Bessel's inequality, Parseval's theorem. Hilbert – adjoint operator, self-ad joint, unitary and normal operators, projection operators. Spectral theory, Fixed point theorem.	**20**

Course Outcomes:

CO1	**MMAT-2402.1**	To explain the concepts of normed linear spaces and its properties.
CO2	**MMAT-2402.2**	To understand bounded, continuous linear operators and linear functional.
CO3	**MMAT-2402.3**	To apply the proof of many theorems for proof of other theorems.
CO4	**MMAT-2402.4**	To learn skills to apply concept of uniform boundedness theorem and open mapping theorem
CO5	**MMAT-2402.5**	Upon successful completion of this course, students would be able to know the use of spectral theory.

Recommended Books :

1. G.F.Simmons, Introduction to Toplogy and modern Analysis, Tata McGraw-Hill Education Pvt. Ltd., 2016

2. George Bachman & Lawrence Narici, Functional Analysis, Dover Publications; Unabridged edition (January 29, 1998).

3. Walter Rudin, Functional Analysis, International Series in Pure and Applied Mathematics, McGrawHill, 1991.

4. S.Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, 2008.

SUBJECT TITLE: Non-Linear Programming
SUBJECT CODE: MMAT-2403
SEMESTER: IV
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To cover the theory of unconstrained and constrained nonlinear optimization.
- To provide knowledge of basic convex analysis, optimality conditions for unconstrained and constrained nonlinear optimization problems and Quadratic programming.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Nonlinear Programming: Convex functions, Concave functions, Definitions and basic properties, sub-gradients of convex functions, Differentiable convex functions, Minima and Maxima of convex function and concave functions. Generalizations of convex functions and their basic properties.	15

UNIT-II	Unconstrained problems, Necessary and sufficient optimality criteria of first and second order. First order necessary and sufficient Fritz John conditions and Kuhn-Tucker conditions for Constrained programming problems with inequality 20 constraints, with inequality and equality constraints. Kuhn Tucker conditions and linear programming problems.	**20**
UNIT-III	Duality in Nonlinear Programming, Weak Duality Theorem, Wolfe's Duality Theorem, Hanson-Huard strict converse duality theorem, Dorn's duality theorem, strict converse duality theorem, Dorn's Converse duality theorem, Unbounded dual theorem, theorem on no primal minimum .Duality in Quadratic Programming	**20**
UNIT-IV	Quadratic programming: Wolfe's method, Beale's method for Quadratic programming. Linear fractional programming method due to Charnes and Cooper. Nonlinear fractional programming, Dinkelbach's approach. Game theory - Two-person, Zero-sum Games with mixed strategies, graphical solution, solution by Linear Programming.	**20**

Course Outcomes:

CO1	**MMAT-2403.1**	To develop an understanding of the foundations of classic continuous optimization problems
CO2	**MMAT-2403.2**	To identify convexity, smoothness, feasible region and dual reformulation in many problems.
CO3	**MMAT-2403.3**	To acquire knowledge for develop familiarity with first and second-order optimization algorithms.
CO4	**MMAT-2403.4**	To learn skills to gain practical knowledge by implementing the algorithms introduced in the course.
CO5	**MMAT-2403.5**	Upon successful completion of this course, students would be able to solve many problems by linear programming.

Recommended Books :

1. Avriel, M. Non-linear programming, Analysis & methods, Englewood Cliffs, Prentice Hall,

1976.
2. Bazaraa, M.S., Sherali, Hanif D and Shetty, C.M., Nonlinear programming: Theory and Algorithm, John Wiley,3rd Edition, 2006.
3. Simmons, D.M., Non-Linear Programming for Operations research, Prentice - Hall,1993.
4. Chander Mohan and Kusum Deep, Optimization Techniques, New Age International, 2009.

SUBJECT TITLE: Theory of Linear Operators
SUBJECT CODE: MMAT-2404
SEMESTER: IV
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To provide theory of Operators and Spectral theory in normed linear spaces, resolvant set and spectrum and Hilbert space to solve problems.
- To identify the suitable computational technique for a specific type of problems.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	Spectral theory in normed linear spaces, resolvant set and spectrum. Spectral properties of bounded linear operator. Properties of resolvant and spectrum.	20

	Spectral mapping theorem for polynomials, spectral radius of bounded linear operator on a complex Banach space.	
UNIT-II	Elementary theory of Banach algebras. Resolvant set and spectrum. Invertible elements, Resolvant equation. General properties of compact linear operators.	**15**
UNIT-III	Spectral properties of compact linear operators on normed space. Behaviour of compact linear operators with respect to solvability of operator equations. Fredholm type theorems. Fredholm alternative theorems.	**20**
UNIT-IV	Spectral properties of bounded self-adjoint linear operators on a complex Hilbert space. Positive operators. Monotone sequence theorem for bounded self-adjoint operators on a complex Hilbert space. Square roots of positive operators. Spectral family of a bounded self-adjoint linear operator and its properties, Spectral theorem.	**20**

Course Outcomes:

CO1	**MMAT-2404.1**	To develop an understanding of the uses of functional analysis.
CO2	**MMAT-2404.2**	To identify the use of ideas of using of functional analysis from vector spaces, the theory of metrics, and complex analysis.
CO3	**MMAT-2404.3**	To acquire knowledge of many theorems and their proofs
CO4	**MMAT-2404.4**	To learn skills to gain knowledge by implementing theory of normed and Banach spaces.
CO5	**MMAT-2404.5**	Upon successful completion of this course, students would be able to use of spectral and elementary theory in different areas.

Recommended Books

1. E. Kreyszic : Introductory Functional Analysis with Applications, Wiley; 1 edition (February 23, 1989)

2. Bachman and Narici : Functional Analysis, Academic Press, Inc., New York, 1966 edition.

SUBJECT TITLE: Integral Transforms
SUBJECT CODE: MMAT-2405
SEMESTER: IV
CONTACT HOURS/WEEK:

Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
4	1	0	5

Internal Assessment: 40
End Term Exam: 60
Duration of Exam: 3 Hrs

Objective:

- To present the foundations of many basic Mathematical tools and to provide a coherent development to the students for the courses of various branches
- To enhance the ability to think logically and mathematically.

Contents of Syllabus:

Sr. No	Contents	Contact Hours
UNIT-I	**Fourier Series:** Fourier Series Theorems, Dirichlet's conditions, Fourier integral formula (without proof) Fourier Series for even and odd functions Half range Fourier series, Other forms of Fourier series	**15**
UNIT-II	**Fourier Transforms and Finite Fourier Transforms**: Dirichlet's conditions Fourier transform Inverse Theorem for Fourier Transform Fourier Sine and Cosine transforms and their inversion formula Linearity property of Fourier transforms Change of Scale property Shifting theorem Modulation theorem Convolution theorem of Fourier transforms Parseval's identity, Finite Fourier Sine transform Inversion formula for Sine transform Finite Fourier Cosine transform Inversion formula for Cosine transform	**20**
UNIT-III	**Laplace and Inverse Laplace Transforms**: Definition of Laplace Transform Linearity property - Piecewise continuous function Existence of Laplace transform Functions of exponential order and of class A First and second shifting theorems of L.T. Change of scale property L.T. of derivatives Initial value problems L.T. of Integrals L.T. of Multiplication by t, L.T. of Division by t, L.T. of periodic functions and error function Beta fn. And Gamma fn. Definition of Inverse Laplace Transform Linearity property First and second shifting theorems of Inverse L.T. Change of scale property Division by p Convolution theorem Heaviside's expansion formula(with proofs and applications)	**20**
UNIT-IV	**Applications of Laplace Transforms** Solution of Ordinary Differential Equations, Solution of Simultaneous Ordinary Differential Equations Solution of Partial Differential Equations Applications of Fourier transforms to initial and boundary value problems.	**20**

Course Outcomes:

CO1	**MMAT-2405.1**	To Calculate the Laplace transform of standard functions both from the definition and by using tables.
CO2	**MMAT-2405.2**	To identify the use of ideas of using of appropriate shift theorems in finding Laplace and inverse Laplace transforms.
CO3	**MMAT-2405.3**	To acquire knowledge of necessary Laplace transform techniques to solve second-order ordinary differential equations involving the Dirac delta.
CO4	**MMAT-2405.4**	To learn skills to demonstrate their understanding of the Dirichlet conditions by using them to evaluate infinite series
CO5	**MMAT-2405.5**	Upon successful completion of this course, students would be able to Calculate the Fourier transform of elementary functions from the definition.

Recommended Books:

1. Integral Transforms by A.R.Vasistha & Dr.R.K.GuptaPublished by Krishna Prakashan Media Pvt. Ltd, Meerut.
2. Operational Mathematics by R.V.Churchill, Mc Graw Hill Company
3. A Course of Mathematical Analysis by Shanthi Narayan and P.K.Mittal, Published by S.Chand & Company