SYLLABUS

M. Sc. MATHEMATICS

PROGRAM CODE: MSMAT

SESSION: 2023-2024

MATA GUJRI COLLEGE
FATEHGARH SAHIB
(AN AUTONOMOUS COLLEGE)
AFFILIATED TO PUNJABI UNIVERSITY, PATIALA

Re-Accredited with Grade 'A' by NAAC

Covered under Star College Scheme, DBT, GOI

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CONTENTS

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

1. ABOUT THE PROGRAMME

Mathematics department was established in 1959 in Mata Gujri College, Fatehgarh Sahib. Initially Mathematics was offered to students of B. Sc Non- Medical and as an elective subject in BA. With the changing scenario, the department started several programmes of pure and applied nature. To meet the latest demands of industry the department keeps on periodically updating and revising its teaching pedagogies, research schemes. Post-Graduation in Mathematics was introduced in 2006-07. Department has produced several mathematicians who are working in Government, Semi-Government and Private Institutes / Universities.

Mathematics courses not only opens the door to career opportunities in teaching and research but also in banking (Government/private sector) and industry. The department has established a software lab with C language and MATEMATICA. Moreover, the SPSS software is also available in the department.

PROGRAM OBJECTIVES (PO)

After the successful completion of this course, the student be able:

PO1 :To motivate for research in mathematical sciences.
PO 2: To train computational scientists who can work on real life challenging problem.
PO 3: To have an in-depth knowledge of a broad range of methods and techniques for analyzing and solving problems with in applicable fields.
PO 4: To have a Good theoretical insight and the ability to apply theory to the development of methods and techniques for solving a problem.
PO 5: To have an in-depth knowledge within a specific mathematical primary field.

PO 6: To tackle complex problems, reveal structures and clarify problems, discover suitable analytical and/or numerical methods and interpret solutions.

PO 7: To communicate clearly in writing and orally knowledge, ideas and conclusions about Mathematics, including formulating complex mathematical arguments, using abstract Mathematical thinking synthesizing intuition about mathematical ideas and their applications.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

PO 8: To demonstrate an advanced knowledge and fundamental understanding of a number of specialist mathematical topics, including the ability to solve problems related to those topics using appropriate tools and techniques.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

PEO-1: To equip students with knowledge, skills and insight in Mathematics and related fields.

PEO-2: To enable students to work as a mathematical professional, or to employ as a scientific researcher.

PEO-3: To develop the ability to utilize the mathematical problem-solving methods such as analysis, modeling, programming and mathematical software applications in addressing the practical issues.

PEO-4: To equip graduates with communication skills, which will allow them to collaborate effectively with other members of a team

PEO 5: To encourage students to recognize the need for and to develop the ability to engage in life-long learning.

PROGRAMME SPECIFIC OUTCOMES(PSO)

The successful completion of this program will enable the students to:

PSO 1: Demonstrate the ability to conduct research independently and pursue higher studies towards the Ph.D. degree in Mathematics.

PSO 2: Carry out development work as well as take up challenges in the emerging areas of Industry.

PSO 3: Demonstrate competence in using mathematical and computational skills to model, formulate and solve real life applications.

PSO 4: Acquire deep knowledge of different mathematical and computational disciplines so that they can qualify NET/ GATE examination.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ORDINANCE

MASTER OF MATHEMATICS

(SEMESTER SYSTEM EXAMINATION)

1. The course for the Degree of Master of MATHEMATICS shall be spread over two academic years to be called M.Sc. Part-I and M.Sc. Part-II. Each part shall consist of two semesters. The examination for the first semester and third semester shall be held in the month of December/January and the examination for the second semester and fourth semester shall be held in the month of April/May or such other dates as may be fixed by the Academic Council.

2. (i)The amount of examination fee to be paid by a candidate for each semester: shall be as prescribed by the college from time to time.

(ii) The medium of examination and instruction shall be English.

(iii) The syllabus shall be such as may be prescribed by the concerned faculty from time to time.

3. (i) Each paper shall have 30% Internal Assessment and at 70% marks for External Examination.

(ii) The internal assessment will be based on all or some of the following:

(1) Average of two internal tests based on lectures delivered

(2) Assignments/reports/projects.

(3) Attendance performance in the class.

(iii) To pass in a paper the candidate must secure 35% marks in the external examination and 35% marks in aggregate (internal and external).

(iv) For a candidate who fails in a paper(s) his internal assessment examination for that paper will be carried over and the supplementary examination will, therefore, consist of only an external examination.

4. The Part-I (M.Sc. 1st Semester) examination shall be open to any person who has been admitted to the course and fulfils the attendance requirements.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELIGIBILITY CONDITION

For admission to M.Sc. Mathematics the candidate should have passed the B.Sc./B.Sc. (Hons)/B. A with Mathematics as a main subject studied in the graduation. The admission of the candidate will be subject to the eligibility conditions in force at the time of admissions:

1. Candidates shall submit their application forms for admission to the Examination duly countersigned by the Head of the Department/Principal of the college along with a certificate from the Head of the Department/Principal of the college that the candidate satisfies the following requirements

(i) Having good moral character, and every candidate will be required to attend 75% of the number of lectures delivered in each paper. For late admission, the candidates, lectures delivered will be counted from his/her date of admission.

(ii) It shall be necessary that 75% of the lectures prescribed for the course in the syllabus are delivered before session in that paper is held.

2. **Subject to above**

(i) There will be no condition of passing papers for promotion from odd semester to even semester in an Academic Session.

(ii) To qualify for admission to 2nd year of the Course, the candidate must have passed 50% of total papers of the two semesters of the 1st year.

(iii) A candidate placed under re-appear in any paper, will be allowed two chances to clear the re-appear, which shall be available within consecutive two years/chances i.e. to pass in a paper the candidate will have a total of three chances, one as regular student and two as re-appear candidate.

(iv) The examination of re-appear papers of odd semester will be held with regular examination of the odd semester and re-appear examination of the even semester will be held with regular examination of even semester. But if a candidate is placed under reappear in the last semester of the course, he will be provided chance to pass the re-appear with the examination of the next semester, provided his reappear of earlier semester does not go beyond that next semester; Provided that for the award of the M.Sc. degree he shall have to qualify in all papers prescribed for the M.Sc. course within a period of four years from the date he joined the course.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

(v) After completion of two academic years of studies (i.e. four semesters) he shall not be admitted to any semester of the same course and will not have any privileges of a regular student.

(vi) The minimum attendance requirement for taking an examination in a paper is 75% of the delivered lectures in that particular paper.

3. The grace marks shall be allowed according to the general ordinances relating to & quot; Award of Grace.

4. Three weeks after the termination of examination or as soon thereafter as possible the Controller of examination shall publish a list of candidates who have passed the examination. Each successful candidates in Part-I examination shall receive a certificate of having passed that examination. A list of successful candidates in Part-II examination be arranged in three Divisions according to Ordinance 10 and the division obtained by the candidate will be stated in his certificate/degree.

5. Successful candidate who obtain 60% or more of the aggregate marks in Part-I and Part-II examination taken together shall be placed in the first division. Those who obtain 50% or more but less than 60% shall be placed in the second division and all below 50% shall be placed in the third division.

6. *A candidate who has passed M.Sc. examination from this college shall have two chances within a period of two years after passing the examination to improve division 55% marks. Improvement shall be allowed in not more than 50% of total theory papers offered in Part-I and Part-II examination. However, previous marks of Internals will be carried forward in the paper(s) in which he appears for improvement.

*Note : Out of papers taken up the candidate, will be given benefit of increase in marks, where the marks have increased in Paper/Papers.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Outline of Programme M. Sc. Mathematics

Semester	Core Course (CC)	Discipline Specific Elective (DSE)
I	**MSMAT 101** Lebesgue Theory of Integration	**MSMAT 102** Advanced Ordinary Differential Equations
	MSMAT 103 Mathematical Statistics	**MSMAT 105** Optimization Techniques
	MSMAT 104 Linear Algebra	**MSMAT 106** Classical Mechanics
II	**MSMAT 201** Algebra-I	**MSMAT 202** Complex Analysis – I
	MSMAT 203 Topology-I	**MSMAT 205** Numerical Analysis
	MSMAT 204 Differential Geometry	**MSMAT 206** Fuzzy Sets and its Applications
III	**MSMAT 301** Algebra-II (Rings And Modules)	**MSMAT 303** Differentiable Manifolds
	MSMAT 302 Functional Analysis	**MSMAT 304** Category Theory-I
	MSMAT 305 Advanced Complex Analysis	**MSMAT 306** Topology II
	MSMAT 307 Non-Parametric Inference	**MSMAT 308** Analytic Number Theory
IV	**MSMAT 401** Theory Of Linear Operators	**MSMAT 403** Lie Groups and Complex Manifolds
	MSMAT 402 Mathematical Methods	**MSMAT 404** Fluid Mechanics
	MSMAT 405 Algebraic Coding Theory	**MSMAT 406** Operations Research
	MSMAT 407 Non Linear Programming	**MSMAT 408** Numerical Solutions of ODE & PDE
	MSMAT409 Algebraic Topology	**MSMAT410** Field Theory
	MSMAT411 Category Theory-II	

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

PANEL		
S. No.	**Name and Affiliation**	**Designation**
1.	Ms. Namita Berry Associate Professor, P.G. Department of Mathematics Mata Gujri College, Fatehgarh Sahib	Chairman
2.	Dr. Shalini Gupta (HOD) Associate Professor, Department of Mathematics Punjabi University Patiala	Vice Chancellor Nominee
3.	Prof. S. S. Dhaliwal Sant Longowal Institute of Engineering and Technology, Longowal.	Nominee of Academic Council
4.	Dr. Sapna Sharma Associate Professor, Thapar Institute of Engineering and Technology	Nominee of Academic Council
5.	Bharat Bhushan Advocate, District Court Fatehgarh Sahib	Industry Expert
6.	Ms. Poonam Chawla Assistant Professor, P.G. Department of Mathematics Mata Gujri College, Fatehgarh Sahib	Member
7.	Ms. Shivdeep Kaur Assistant Professor, P.G. Department of Physics Mata Gujri College, Fatehgarh Sahib	Member
8.	Mr. Sham Bansal Assistant Professor, P.G. Department of Mathematics Mata Gujri College, Fatehgarh Sahib	Member
9.	Dr. Rajinder Pal Assistant Professor, P.G. Department of Mathematics Mata Gujri College, Fatehgarh Sahib	Member

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

PROGRAMME STRUCTURE

Semester	Core courses			Elective Course			Open Elective			Total Credits
	No of Papers	Credits LTP	Total Credits	No of Papers	Credits LTP	Total Credits	No of Papers	Credits LTP	Total Credits	
I	04	06 5 1 0	24	01	06 5 1 0	06	Nil	----	----	30
II	04	06 5 1 0	24	01	06 5 1 0	06	Nil	----	----	30
III	02	06 5 1 0	12	03	03 5 1 0	18	Nil	----	----	30
IV	02	06 5 1 0	12	03	03 5 1 0	18	Nil	----	----	30

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SEMESTER WISE DETAILS OF THE PROGRAMME

Course Code	Course Name	Credits L T P	External Marks	Internal Assessment	Total
Semester-I					
MSMAT 101	Lebesgue Theory of Integration	5 1 0	70	30	100
MSMAT 102	Advanced Ordinary Differential Equations	5 1 0	70	30	100
MSMAT103	Mathematical Statistics	5 1 0	70	30	100
MSMAT 104	Linear Algebra	5 1 0	70	30	100
MSMAT 105	Optimization Techniques	5 1 0	70	30	100
MSMAT 106	Classic Mechanics	5 1 0	70	30	100
Total credit		30	-	-	500
Semester II					

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

MSMAT 201	Algebra-I	5 1 0	70	30	100
MSMAT 202	Complex Analysis – I	5 1 0	70	30	100
MSMAT 203	Topology-I	5 1 0	70	30	100
MSMAT 204	Differential Geometry	5 1 0	70	30	100
MSMAT205	Numerical Analysis	5 1 0	70	30	100
MSMAT 206	Fuzzy Sets and its Applications	5 1 0	70	30	100
Total credit		30	-	-	500
Semester III					
MSMAT 301	Algebra-II (Rings and Modules)	5 1 0	70	30	100
MSMAT 302	Functional Analysis	5 1 0	70	30	100
MSMAT 303	Differentiable Manifolds	5 1 0	70	30	100

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

MSMAT 304	Category Theory-I	5 1 0	70	30	100
MSMAT 305	Advanced Complex Analysis	5 1 0	70	30	100
MSMAT 306	Topology II	5 1 0	70	30	100
MSMAT 307	Non-Parametric Inference	5 1 0	70	30	100
MSMAT 308	Analytic Number Theory	5 1 0	70	30	100
Total credit		30	-	-	500
Semester IV					
MSMAT 401	Theory Of Linear Operators	5 1 0	70	30	100
MSMAT 402	Mathematical Methods	5 1 0	70	30	100
MSMAT 403	Lie Groups and Complex Manifolds	5 1 0	70	30	100
MSMAT 404	Fluid Mechanics	5 1 0	70	30	100
MSMAT	Algebraic Coding	5 1 0	70	30	100

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

405	Theory				
MSMAT 406	Operations Research	5 1 0	70	30	100
MSMAT 407	Non Linear Programming	5 1 0	70	30	100
MSMAT 408	Numerical Solutions of ODE & PDE	5 1 0	70	30	100
MSMAT409	Algebraic Topology	5 1 0	70	30	100
MSMAT410	Field Theory	5 1 0	70	30	100
MSMAT411	Category Theory-II (Pre-Requisite **CATEGORY THEORY-I)**	5 1 0	70	30	100
Total credit		30	-	-	500
Total credits for M.Sc. = 120					

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SYLLABUS
M.Sc. Mathematics (Part-I)
Session 2023-2024
Semester –I

Course Code	Course Name	Credits L T P	External Marks	Internal Assessment	Total
Core course MSMAT 101	Lebesgue Theory of Integration	5 1 0 (6)	70	30	100
Core Course MSMAT 102	Advanced Ordinary Differential Equations	5 1 0 (6)	70	30	100
Core Course MSMAT 103	Mathematical Statistics	5 1 0 (6)	70	30	100
Core Course MSMAT 104	Linear Algebra	5 1 0 (6)	70	30	100
CHOOSE ANY ONE OF THE FOLLOWING ELECTIVE COURSES					
Elective Course MSMAT 105	Optimization Technique	5 1 0 (6)	70	30	100
Elective Course MSMAT 106	Classical Mechanics	5 1 0 (6)	70	30	100
Total		30			500

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE
MSMAT 101: LEBESGUE THEORY OF INTEGRATION

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course Objectives: The objective of this subject is to introduce students to understand the importance of measure theory and Integration.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand the fundamental concepts of outer measures, Lebesgue measure and non-measurable sets.
- Be familiar with outer measure, Lebesgue measurable functions
- To understand integrate a measurable function and classical theorems of Lebesgue theory.
- Understand the concept of Function of Bounded Variations and Differentiation of an integral.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Outer measure and its properties, measurable sets an Lebesgue measure, algebras and σ- algebra of Lebesgue measurable sets, outer and inner approximation of Lebesgue measurable sets, countable additivity and continuity of Lebesgue measure, measurability of Borel sets and Cantor set, non-measurable sets.

Measurable functions, sequential point wise limits of measurable function, Borel measurable function, Littlewood's Three Principles, Egroff's theorem and Lusin's Theorem

[scope as in chapter-3 of R&S-1(3.1-3.6)]

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-B

Lebesgue integral of bounded function over a set of finite measure, Linearity and monotonicity of integration, Bounded convergence theorem, Integration of non-negative measurable functions, Fatou's lemma, Monotone convergence theorem, The general Lebesgue integral, Lebesgue dominated convergence theorem, General Lebesgue dominated convergence theorem, countable additivity and continuity of integration, [Scope as in Chapter-4 of R&S-1]

Vitali covering lemma, Lebesgue's Theorem, Functions of bounded variations, Jordan's Theorem, Differentiation of an integral, absolute continuity.
[Scope as in chapter -5(5.1-5.4), of R&S-1]

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. H.L. Royden: Real analysis, Macmillan Pub. co. Inc. 4th Ed., New York, 1993. Chapters 3, 4, 5 and Sections 1 to 4 of Chapter 11.
2. T. M. Apostal, Mathematical Analysis, 2ndEd., Narosa Publishing House.
3. W. Rudin: Real and Complex Analysis, 3rd edition, McGrawHill, Education, 2017, Indian Edition. Chapter 2 (Sections 2.15-2.30).
4. S.C. Malik and Savita Arora: Mathematical Analysis, New Age International Publishers.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.
Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.
Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.
Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.
Seminars: Seminars are conducted for overall personality development, to prepare them for Interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE

MSMAT 102: ADVANCED ORDINARY DIFFERENTIAL EQUATIONS

L T P
5 1 0
Pass percentage: 35%
External Examination Time: 3 hours.

Duration: 60 Hours
External Evaluation: 70
Internal Assessments: 30

Course objectives: The general purpose of this course is to introduce basic concepts of the theory of ordinary differential equations, to give several methods including the series method for solving linear and nonlinear differential equations, to learn about existence and uniqueness of the solution to the nonlinear initial value problems.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand the fundamental concepts of differential equations like existence of solution of ODE of first order, initial value problem, Ascoli's Lemma, Gronwall's inequality, Cauchy Peano Existence Theorem, Uniqueness of Solutions.
- Learn and derive the solutions of existence and uniqueness theorems for system and higher order equations, linear system of equations, fundamental set of solutions, Abel Liouville formula.
- Learn the concept of separation theorem, Sturm's fundamental comparison theorem, Sturm Liouville boundary value problem.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-A

Existence and uniqueness of solution of ODE of first order, initial value problem, Ascoli's Lemma, Gronwall's inequality, Cauchy Peano Existence Theorem, Uniqueness of Solutions. Method of successive approximations, Existence and Uniqueness Theorem. System of differential equations, nth order differential equation, Existence and Uniqueness theorems for system and higher order equations, dependence of solutions on initial conditions and parameters. [R&S 1: Chapter 1 (Sections 1, 2, 3, 4, 5 and 6), Text 2: Chapter 10 (Sections 10.2, 10.3 and 10.4)]

SECTION- B

Linear system of equations (homogeneous & non homogeneous). Superposition principle, Fundamental set of solutions, Fundamental Matrix, Wronskian, Abel Liouville formula, Reduction of order, Adjoint systems and self adjoint systems of second order, Floquet Theory. Linear 2^{nd} order equations, preliminaries, Sturm's separation theorem, Sturm's fundamental comparison theorem, Sturm Liouville boundary value problem, Characteristic values & Characteristic functions, Orthogonality of Characteristic functions, Expansion of a function in a series of orthonormal functions.
[R&S 2: Chapter 11, Chapter 12 (Sections 12.1, 12.2 and 12.3)]

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. Earl A. Coddington& Norman Levinson: Theory of Ordinary Differential Equations, Tata Mc-Graw Hill, India.9th Ed., 1987.
2. S. L. Ross: Differential Equations, 3^{rd} Ed., John Wiley & sons, 1984 Asia.
3. D. A. Sanchez: Ordinary Differential Equations & Stability Theory, Freeman & company. 1968
4. A. C. King, J. Billingham& S. R. Otto: Differential Equations, Linear, Nonlinear, Ordinary, Partial, Cambridge University Press, 2003.
5. W.E. Boyce & R.C. DiPrima, Elementary Differential Equations, 9^{th}Ed., Wiley,2008.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for Interviews and class teaching. This will help them in further placement

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE
MSMAT 103: MATHEMATICAL STATISTICS

L T P
5 1 0

Duration: 60 Hours
External Evaluation: 70
Internal Assessments: 30
Pass percentage: 35%
External Examination Time: 3 hours.

Course objectives: Statistical methods used in practice are based on the foundations of the statistical theory. One branch of this theory uses the tools of probability to establish important distributional results that are used throughout statistics. Another major branch of statistical theory is statistical inference. This basic course toward the first branch is concerned with the fundamental theory of probability, random variables, Expectation, Distributions. Students will be familiar with many common distributions, continuous or discrete, univariate or multivariate, which provides rich families for modeling real data.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand the concept of Probability distributions.
- Find mathematical expectation, moments, moment generating functions, product moments, moments of linear combinations of random variables, conditional expectations.
- Be familiar with study of various discrete distributions and continuous distributions.
- Be able apply test of significance and find point estimation.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-A

Probability distributions and Probability densities: random variables, probability distributions, continuous random variables, probability density functions, multivariate distributions, joint distribution, marginal distribution and conditional distribution, independence of random variables, mathematical expectation, moments, Chebyshev's theorem, moment generating functions, product moments, moments of linear combinations of random variables, conditional expectations. [R &S-1]

Study of various discrete distributions: Discrete Uniform distribution, Bernoulli distribution, Binomial distribution, Hyper-geometric distribution, Poisson distribution, Poisson distribution as a limiting case of Binomial distribution. [R&S-2]

SECTION-B

Study of various continuous distributions: Uniform distribution, Normal distribution, The Normal approximation to the Binomial distribution, Gamma distribution, Exponential distribution, Beta distribution. Statistical Hypothesis: Introduction, Null and Alternative hypothesis, Level of Significance, Critical Region, Type I & Type II errors, Test of Significance: large sample test: Z-test (single mean & difference of means), Small sample test: t-test (single mean, difference of means), Chi-square goodness of fit test, F-test for equality of two population variances. [R&S-2]

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. Irwin Miller, Marylees Miller: John E. Freund's Mathematical Statistics with Applications, Pearson New International Edition, 8th Edition, Pearson Education Limited.
2. S.C Gupta & V.K. Kapoor: Fundamental of Mathematical Statistics, Sultan Chand & Sons, 11th edition.
3. A. M. Gun, M.K. Gupta and B. Dasgupta: An Outline of Statistical Theory, Volume two, 3rd edition, The World Press Private Limited.
4. Robert V. Hogg, Joeseph McKean, Allen T. Craig: Introduction to Mathematical Statistics, 7thedition, Pearson.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for Interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE

MSMAT 104-LINEAR ALGEBRA

L T P Duration: 60 Hours

5 1 0 External Evaluation: 70

Pass percentage: 35% Internal Assessments: 30

External Examination Time: 3 hours.

Course objectives: The objective of this subject is to introduce students to understand the importance of Linear Algebra to improve the ability to think logically, analytically, and abstractly.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand the concepts of linear transformation, the algebra of linear transformation.
- Understand isomorphism, representation of transformations by matrices, linear functional, and the transpose of linear transformation.
- Understand characteristic values, annihilating polynomials, invariant subspaces, simultaneous triangulation, simultaneous diagonalization.
- Understand the concept of direct sum decompositions, invariant direct sums and primary decomposition theorem. Learn the Rational and Jordan forms and inner product spaces and their applications.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Linear Transformations: Introduction to Linear Transformation, the Algebra of Linear Transformation, Isomorphism, Representation of Transformations by Matrices, Linear Functional, the Transpose of Linear Transformation.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Elementary Canonical forms: Characteristic values, Annihilating polynomials, Invariant subspaces, simultaneous triangulation, simultaneous diagonalization, direct sum decompositions, Invariant direct sums, the primary decomposition theorem. (Chapter 3 and 6 of R&S 1).

SECTION-B

The rational and Jordan forms: Cyclic subspaces and Annihilators, Cyclic decomposition and the rational forms, The Jordan form, computation of Invariant factors.

Inner product space: Introduction to Inner product space, Cauchy-Schwarz inequality, Holder inequality, Gram-Schmidt orthogonalization process, Bessel inequality. (Chapter 7 and section 8.1 and 8.2 of chapter 8 of R & S 1).

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. K. Hoffmann & R. Kunze: Linear algebra, 2nd Ed., PHI.
2. Vivek Sahai & Vikas Bist: Linear Algebra, Narosa Publishing House, 2002.
3. P. R. Halmos: Finite Dimensional Vector Space, Springer-Verlag New York.
4. Serge Lang: Linear Algebra, Springer-Verlag Undergraduate Text in Mathematics.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for Interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE
MSMAT 105-OPTIMIZATION TECHNIQUES

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: To train the student in the domain of linear programming. To give sufficient tools for solving linear programming problems which can be used by students for further applications in different areas of interest.

Course Learning Outcomes: Upon the completion of this course, students will be able to:

- Formulate, Understand and apply the concept of optimality criteria for various type of optimization problems.
- Solve the transportation and assignment problems.
- Identify strategic situations and represent them as games.
- Apply the methods of optimization in real life situation.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Introduction, definition of operation research, models in operation research, general methods for solving O.R. models. Elementary theory of convex sets, Linear programming problems, examples of LPPs, mathematical formulation of the mathematical programming problems, Graphical solution of the problem. Simplex method, Big M method, Two Phase method, problem of degeneracy.

Duality in linear programming: Concept of duality, fundamental properties of duality, duality theorems, complementary slackness theorem, duality and simplex method, dual simplex method.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Sensitivity Analysis: Discrete changes in the cost vector, in the requirement vector and in the co-efficient matrix.

SECTION-B

Transportation Problem: Introduction, mathematical formulation of the problem, initial basic feasible solution, optimum solution, degeneracy in transportation problems, transportation algorithm, unbalanced transportation problems. Assignment Problems: Introduction, mathematical formulation of an assignment problem, assignment algorithm, unbalanced assignment problems.

Integer Programming: Introduction, Gomory's all-IPP method, Gomory's mixed-integer method, Branch and Bound method. Games and Strategies: Introduction, Two person zero sum games, Maximum, Minimum, Principle; Games without saddle points, Mixed Strategies, Graphical solution, Dominance property, Reducing the game problem to a LPP.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Kanti Swarup, P. K. Gupta and Man Mohan: Operations Research, Sultan Chand and Sons, New Delhi, 2010.
2. Chander Mohan and Kusum Deep: Optimization Techniques, New Age International, 2009.
3. H. Taha: Operation Research an Introduction, Pearson, 2010.
4. G. Sriniwasan: Operation Research Principle & Application, Printice Hall.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for Interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE
MSMAT 106: CLASSICAL MECHANICS

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: Course objectives: This course is intended to provide a treatment of basic knowledge in mechanics used in deriving a range of important results and problems related to rigid bodies the objective is to provide the student the classical mechanics' approach to solve a mechanical problem.

Course Learning Outcomes: Upon the completion of this course, students will be able to:

- Understand the concept Basic Principles of Mechanics of a Particle and a System of Particles.
- Be able to understand Variational Principles and Lagrange's Equations and understand Conservation Theorems and Symmetry Properties.
- Be familiar with the Two-Body Central Force Problem One Dimensional Problem and the Classification of Orbits, The Virial Theorem, Conditions for Closed Orbits, Bertrand's Theorem.
- Understand the Kepler Problem: Inverse Square Law of Force, The Motion in Time in the Kepler Problem, Kepler's Laws, Kepler's Equation, The Laplace-Runge-Lenz Vector.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Basic Principles: Mechanics of a Particle and a System of Particles, Constraints, Generalized Coordinates, Holonomic and Non-Holonomic Constraints. D'Alemberts Principle and Lagrange's

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Equations, Velocity Dependent Potentials and the Dissipation Function, Simple Applications of the Lagrangian formulation. Variational Principles and Lagrange's Equations: Hamilton's Principle, Derivation of Lagrange's Equations from Hamilton's Principle, Extension of Hamilton's Principle to Non-Holonomic Systems.

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

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

SECTION – B

The Kepler Problem: Inverse Square Law of Force, The Motion in Time in the Kepler Problem, Kepler's Laws, Kepler's Equation, The Laplace-Runge-Lenz Vector. Scattering in a Central Force Field: Cross Section of Scattering, Rutherford scattering Cross Section, Total Scattering Cross Section, and Transformation of the Scattering Problem to Laboratory Coordinates. The Kinematics of Rigid Body Motion: The Independent Coordinates of Rigid Body, The Transformation Matrix, The Euler Angles, The Cayley-Klein Parameters and Related Quantities, Euler's Theorem on the Motion of Rigid Bodies, Finite Rotations, Infinitesimal Rotations, The Coriolis Force.

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. Herbert Goldstein: Classical Mechanics, 2nd edition, Narosa Publishing.
2. F. Chorlton: Text Book of Dynamics, CBS New Delhi (1985),1st Edition.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for Interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SYLLABUS
M.Sc. Mathematics (Part-I)
Session 2023-2024

Semester –II

Course Code	Course Name	Credits L T P	External Marks	Internal Marks	Total Marks
Core course MSMAT 201	Algebra-I	5 1 0 (6)	70	30	100
Core Course MSMAT 202	Complex Analysis – I	5 1 0 (6)	70	30	100
Core Course MSMAT 203	Topology-I	5 1 0 (6)	70	30	100
Core Course MSMAT 204	Differential Geometry	5 1 0 (6)	70	30	100
CHOOSE ANY ONE OF THE FOLLOWING ELECTIVE COURSES					
Elective Course MSMAT 205	Numerical Analysis	5 1 0 (6)	70	30	100
Elective Course MSMAT 206	Fuzzy Sets and its Applications	5 1 0 (6)	70	30	100
Total		30			500

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE
MSMAT 201: ALGEBRA-I

L T P
5 1 0
Pass percentage: 35%
External Examination Time: 3 hours.

Duration: 60 Hours
External Evaluation: 70
Internal Assessments: 30

Course objectives: The objective of the course is to introduce basic structures of algebra like groups, rings, fields and vector spaces which are the main pillars of modern mathematics. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.
Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand normal and subnormal series, solvable groups, nilpotent groups, composition series.
- Derive Jordan-Holder theorem for groups, permutation groups and the structure theory of groups.
- Derive fundamental theorem of finitely generated abelian groups, Sylow's theorems and groups of order p^2, pq.
- Understand ideals, algebra of ideals, maximal and prime ideals, ideal in quotient rings and learn the concepts of field of quotients of integral domain and rings of endomorphisms of abelian groups.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Review of groups, Normal and subnormal series, Solvable groups, Nilpotent groups, Composition Series, Jordan-Holder theorem for groups. Group action, Stabilizer, orbit, Class equation and its

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

applications permutation groups, cyclic decomposition, conjugacy classes in permutation groups. Alternating group A_n, Simplicity of A_n.

SECTION-B

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

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Bhattacharya, Jain & Nagpaul: Basic Abstract Algebra, Cambridge University Press, 2nd Ed., 1994. (Ch. 6, 7, 8, 10)
2. Surjeet Singh & Qzai Zimeeruddin: Modern Algebra, 8th Ed., Vikas Publishing House, 2006.
3. I. N. Herstein: Topics in Algebra, Second Ed., Wiley, 2006.
4. J. B. Fraleigh: A First Course In Abstract Algebra, 7th Ed., Pearson, 2002.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for Interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE

MSMAT 202: COMPLEX ANALYSIS-I

L	T	P	
5	1	0	

Duration: 60 Hours
External Evaluation: 70
Internal Assessments: 30
Pass percentage: 35%
External Examination Time: 3 hours.

Course objectives: This course is aimed to provide an introduction to the theories for functions of a complex variable. It begins with the exploration of the algebraic, geometric and topological structures of the complex number field. The concepts of analyticity, Cauchy-Riemann relations, and harmonic functions are then introduced. Students will be equipped with an understanding of the fundamental concepts of complex variable theory. In particular, students will acquire the skill of contour integration to evaluate complicated real integrals via residue calculus.

Course Learning Outcomes: Upon completion of this course, students should be able to

- Represent complex numbers algebraically, geometrically and analyze limits and continuity for complex functions as well as consequences of continuity.
- Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra.
- Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula
- Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-A

Complex Differentiation: Functions of a complex variable, Limits, Continuity, Differentiability. Analytic function, Cauchy-Riemann equations (Cartesian and polar form), Harmonic function and Harmonic conjugates, construction of analytic functions. Branch cut and Branch point.
Complex Integration: Line integral, Cauchy's theorem, Cauchy Goursat theorem, Cauchy's Integral formula, Cauchy's inequality, Poisson's integral formula, Morera's theorem, Liouville's theorem, Fundamental theorem of Algebra.

SECTION-B

Power series, Taylor's series, Laurent's series. Maximum Modulus Principle, Minimum Modulus Principle, Schwarz's Lemma. Zeros and Singularities of a function, Meromorphic and entire functions: Residues at a pole and at infinity, Cauchy's theorem on residues, Argument Principle, Rouche's theorem, Fundamental Theorem of Algebra. Conformal Mappings: Transformation, Angle of rotation**,** Magnification, Inversion. Bilinear transformation: Critical points, Fixed points, Cross ratio problems, Normal form.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. J. W. Brown & R.V. Churchill: Complex Variables and Applications, McGraw Hill, 2009.
2. S. Ponnusamy: Foundations of Complex Analysis, Narosa Publishing House,2019.
3. E. T. Copson: An introduction to Theory of Functions of a Complex Variable, Oxford University Press, 1970.
4. L. V. Ahlfors: Complex Analysis, 3rd Ed., McGraw Hill, 2000.
5. S. Ponnusamy, Herb Silverman: Complex Variables with applications, Birkhäuser, 2006.
6. D. G. Zill and P. D. Shanahan: A First Course with Application, 3rd edition, Jones & Bartlett Learning, 2015.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE
MSMAT 203: TOPOLOGY I

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course Objectives: A firm understanding of fundamental abstract topological structures and properties, and fluency in using the language of topology, analyzing structures, discovering common features, discriminating characteristic properties, abstracting their essence, making assumptions, constructing counterexamples, making definitions, formulating theorems and creating proofs.
Course Learning Outcomes: Upon completion of this course, students should be able to:

- Define and illustrate the concepts of the Metric Spaces.
- Define and illustrate the concept of topological spaces and continuous functions.
- Define and illustrate the concept of product topology.
- Define connectedness and compactness, and prove a selection of related theorems**.**

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Metric Spaces: Definition, open sets, limit points, closed sets, subspaces, closure of a set, interior, exterior of a set, Frontier and boundary points, Dense sets.
Topological Spaces: Definition and examples, Euclidean spaces as topological spaces, Basis for a given topology, Topologizing of Sets; Sub-basis, Equivalent Basis.
Elementary Concepts: Closure, Interior, Frontier and Dense Sets, Topologizing with pre- assigned elementary operations. Relativization, Subspaces.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Maps: Continuous Maps, Restriction of Domain and Range, Characterization of Continuity, Continuity at a point. Open Maps and Closed Maps, Homeomorphisms and Embeddings.

SECTION-B

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

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

Compactness and Countability: Compactness and Countable Compactness, Local Compactness

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. W. J. Pervin: Foundations of General Topology, Academic Press Inc., 1964. Section 4.2.
2. James Dugundji: TOPOLOGY, William C Brown Pub, 1966. (Relevant Portions from Ch. III (excluding Sec 6 and Sec 10), Ch IV; (Sections 1-3) and Ch V).
3. James Munkers: Topology, 2nd Ed., Printice Hall, Indian Learning Pvt. Ltd.
4. Sheldon W. Davis: Topology; Tata McGraw-Hill Ed., 1899.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE
MSMAT 204: DIFFERENTIAL GEOMETRY

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course Objectives: The main aim is to make students familiar with contour integrals and residue theory for finding contour integrals. It is expected that on successful completion of this course the students will be able to handle contour integrals and its applications with mathematical maturity.
Course Learning Outcomes: Upon completion of this course, students should be able to:

- Explain the concepts of space curves and t, n, b frame, its fundamental properties.
- Understand the concept of intrinsic properties of space curves and Helices, involutes evolutes
- Understand the concept of surface and its Fundamental forms.
- Obtain sound knowledge in understanding the concepts Geodesics.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each of marks 10 from the respective sections of the syllabus. Sections C will consist of ten short questions each of marks 3 covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Curves in space, arc length, contact of nth order of curve and surface, tangent, principle normal and binormal, curvature and torsion of space curve, Serret- Frenet formulae, osculating plane, osculating circle and osculating sphere, Locus of centers of osculating circle and osculating sphere, intrinsic equations of space curves, Fundamental Theorem of space curves, Helices, Properties of Helices, Involutes and Evolutes of a curve, Curvature and torsion of involutes and evolutes,

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-B

First Fundamental Form and Second Fundamental Form of a Surface and their geometrical interpretation, Tangent and Normal planes of Surface, Weingarton Equation, angle between parametric curves, direction coefficients and ratios, family of curves, orthogonal trajectories, double family of curves, Curvature of Normal section, Meusnier's Theorem, Principal Directions and Principal Curvature, Gaussian Curvature, Minimal surfaces, Lines of Curvature, Rodrigue's formula, Geodesics, normal property of geodesic, differential equation of geodesic using normal property.

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. A. Pressley: Elementary Differential Geometry, 4th Ed., Springer, 2009
2. D. Somasundaram: Differential Geometry, Narosa Publishing House, 2014.
3. A. Goetz: Introduction to differential geometry, Addison-Wesley Educational Publishers Inc, 1970.
4. T. J. Willmore: An introduction to differential geometry, Oxford University Press India, 1997.
5. Erwin Kreyszig: Differential Geometry, Dover Publications Inc., 1991.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE CORSE
MSMAT 205: NUMERICAL ANALYSIS

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: The course is intended as a basic course in numerical analysis. The objective of the course is to familiarize the students about different numerical techniques e.g. solving algebraic and transcendental equations, large linear system of equations, differential equations, approximating functions by polynomials up to a given desired accuracy, finding the approximate value of definite integrals of functions etc. The course also throws light on the convergence analysis of these techniques and explains different types of errors which get involved and propagates during numerical computations.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Derive numerical methods for approximating the solution of problems of continuous mathematics.
- Analyze the error incumbent in any such numerical approximation.
- Implement a variety of numerical algorithms using appropriate technology.
- Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation, numerical differentiation and integration, solution of linear systems.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

Note: Non-Programmable Scientific Calculator is allowed.

INSTRUCTIONS FOR THE CANDIDATES

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-A

Error Analysis: Absolute, Relative, Percentage, Inherent, Rounding, Truncation errors. Solution of Transcendental and Polynomial equations: Bisection method, Regula-Falsi method, Secant method, Newton- Raphson method, General Iteration methods and their rate of convergence, Newton's method for multiple roots.

Direct Methods: Gauss Elimination method, Partial Pivoting, Complete pivoting, Gauss-Jordan Elimination method, Decomposition methods (LU and Cholesky), Iterative Methods: Jacobi iterative method, Gauss-Seidel iterative method, Successive over relaxation iterative method.

SECTION-B

Eigen Value Problems: Gerschgorin Theorem, Jacobi, Givens methods Householder's method for Symmetric matrices, Power and Inverse Power methods.

Lagrange and Newton Interpolations: Divided differences (Definition and properties), Newton's divided difference formula, Lagrange's interpolation formula, Finite difference operators.

Numerical Differentiation, Error in Numerical Differentiation, Numerical Integration: Newton Cotes formulae: Trapezoidal Rule, Simpson's 1/3-Rule, Simpson's 3/8-Rule, Boole's and Weddle's Rule, Picard's Method, Taylor's Series method, Euler's and modified Euler's methods, Runge- Kutta methods.

RECOMMENDED AND SUGGESTED READINGS (R&S):

1. M. K. Jain, S. R. K lyenger and R. K Jain: Numerical Methods for Scientific and Engineering Computations, 6th Edition, New Age International (P) Limited, Publishers, New Delhi.

2. Kendall E. Atkinson: An introduction to Numerical Analysis, 2nd Edition John Wiley & Sons, Printed in India by Replika Pvt. Ltd., 1989.

3. S. S. Sastry: Introductory Methods of Numerical Analysis, 4th Edition (2010), Prentice Hall of India Pvt. Ltd., New Delhi.

4. F. B. Hilderbrand: Introduction to Numerical Analysis, 2nd Edition, Dover Publication Inc, New York, 1987.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT 206: FUZZY SETS & ITS APPLICATIONS

L T P
5 1 0
Pass percentage: 35%
External Examination Time: 3 hours.

Duration: 60 Hours
External Evaluation: 70
Internal Assessments: 30

Course objectives: The objective of this course is to teach the students the need of fuzzy sets, arithmetic operations on fuzzy sets, fuzzy relations, possibility theory, fuzzy logic, and its applications.

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

- Understand fuzzy sets and fuzzy set operations and fuzzy relation and fuzzy logic.
- Solve fuzzy relation equation and perform fuzzy arithmetic operations.
- Find fuzziness and uncertainty of fuzzy and classical sets and handle the real-world problem in engineering having uncertain and imprecise data.
- Find the optimal solution of mathematical programming problems having uncertain and imprecise data.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Fuzzy Sets: Introduction to fuzzy sets. Membership Function, Compliment, Intersections, Unions, α-cuts, Properties of α-cuts, Decomposition Theorems, Extension Principle. Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on intervals and Numbers, Lattice of Fuzzy

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Numbers, Fuzzy Equations. Uncertainty based Information: Information and Uncertainty, Non-specificity of Fuzzy and Crisp sets, Fuzziness of Fuzzy Sets.

SECTION-B

Fuzzy Relations: Crisp and Fuzzy Relations, Projections and Cylindrical Extensions, Binary Fuzzy Relations, Binary Relations on single set, Equivalence, Compatibility and Ordering Relations, Morphisms, Fuzzy Relation Equations. Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges, Inference from conditional fuzzy positions, Inference from conditional and qualified propositions, Inference from quantified propositions. Fuzzy Linear Programming.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. G.J. Klir and B. Yuan: Fuzzy sets and Fuzzy logic: Theory and Applications, PHI, 1995.
2. G.J. Klir. and T.A. Folyger: Fuzzy Sets: Uncertainty and Information, PHI,1988.
3. H.J. Zimmermann: Fuzzy Set Theory and its Applications, Allied Publishers, 1991.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject.

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SYLLABUS

M.Sc. Mathematics (Part-II)

Session 2023-2024(Semester –III)

Course Code	Course Name	Credits L T P	External Marks	Internal Marks	Total Marks
Core course MSMAT 301	ALGEBRA-II (RINGS AND MODULES)	5 1 0 (6)	70	30	100
Core Course MSMAT 302	FUNCTIONAL ANALYSIS	5 1 0 (6)	70	30	100
CHOOSE ANY THREE OF THE FOLLOWING ELECTIVE COURSES					
Elective Course MSMAT 303	DIFFERENTIABLE MANIFOLDS	5 1 0 (6)	70	30	100
Elective Course MSMAT304	CATEGORY THEORY-I	5 1 0 (6)	70	30	100
Elective Course MSMAT 305	ADVANCE COMPLEX ANALYSIS	5 1 0 (6)	70	30	100
Elective Course MSMAT306	TOPOLOGY II	5 1 0 (6)	70	30	100
Elective Course MSMAT307	NON-PARAMETRIC INFERENCE	5 1 0 (6)	70	30	100
Elective Course MSMAT 308	ANALYTIC NUMBER THEORY	5 1 0 (6)	70	30	100
Total		30			500

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE

MSMAT 301-ALGEBRA-II (RINGS AND MODULES)

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: The main objective of this course is to maintain the standard computations of ring theory and to learn the elementary theorems and proof techniques of group and ring theory. To apply the theorems, proof techniques and standard computations of ring theory to solve problems.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand the concept of unique factorization domains, principal ideal domains, Euclidean domains, polynomial rings over UFD, rings of fractions.
- Understand the concept of modules, submodules, direct sum of submodules, free modules, difference between modules and vector spaces, quotient modules, Homomorphism, simple modules, modules over PID.
- Learn the concept of modules with chain conditions, artinian modules, noetherian modules, artinian Implies noetherian in rings, composition series of a module, length of a module, Hilbert Basis Theorem.
- Learn the concept of Cohen Theorem, Radical Ideal, Nil Radical, Jacobson Radical, radical of an artinian ring. Nil Radical and Jacobson Radical of Polynomial Rings R[x], R commutative.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION –A

Unique Factorization Domains, Principal Ideal Domains, Euclidean Domains, Polynomial Rings over UFD, Rings of Fractions. (R&S1: Ch. 11 and Section 1 of Chapter 12).

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Modules: Definition and Examples, Sub modules, Direct sum of sub modules, Free modules, Difference between modules and vector spaces, Quotient modules, Homomorphism, Simple modules, Modules over PID. (R&S2: Chapter 5)

SECTION - B

Modules with chain conditions: Artinian Modules, Noetherian Modules, Artinian Implies Noetherian in Rings, Composition series of a module, Length of a module, Hilbert Basis Theorem (R&S2: Chapter 6). Cohen Theorem, Radical Ideal, Nil Radical, Jacobson Radical, Radical of an Artinian ring. Nil Radical and Jacobson Radical of Polynomial Rings R[x], R commutative. (R&S2: Chapter 6)

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Bhattacharya, Jain and Nagpaul: Basic Abstract Algebra, Second Ed., Cambridge University Press, 2013.
2. C. Musili: Introduction to Rings and Modules, 5thEd., Narosa Publishing House, 2013.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE

MSMAT302: FUNCTIONAL ANALYSIS

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: The main aim of this course is to provide students basic concepts of functional analysis to facilitate the study of advanced mathematical structures arising in the natural sciences and the engineering sciences and to grasp the newest technical and mathematical literature.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Explain the fundamental concepts of functional analysis Normed Linear spaces, Banach spaces.
- Understand the definitions of linear functional and prove the Hahn-Banach theorem, open mapping theorem, uniform boundedness theorem, etc.
- Understand concepts of Hilbert and Banach spaces with l2 and lp spaces serving as examples.
- Define linear operators, self-adjoint, isometric and unitary operators on Hilbert spaces.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

spaces and its applications. Uniform boundedness principle, Open mapping theorem, Projections on Banach spaces, closed graph theorem.

SECTION-B

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

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. E. Kreyszig: Introductory Functional Analysis with applications, Wiley publishing, 2011.
2. G. Bachman & N. Lawrence: Functional Analysis, Dover publications, 1st Edition, 2000.
3. D. Somasundram: Functional Analysis, Narosa Publishing House, 2018
4. G. F. Simmons: Introduction to Toplogy and Modern Analysis, Chapters IX, X , XII and appendix one.
5. A. H. Siddiqi: Applied Functional Analysis, Springer publication, 1st Edition, 2019.
6. S. Ponnusamy: Foundations of functional analysis, Narosa Publishing house, 2009.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT 303: DIFFERENTIABLE MANIFOLDS

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: This course is a basic course in manifolds. The course starts with a review of multi-variable calculus. This is followed by an introduction to basic concepts related to manifolds and their tangent and cotangent spaces, and forms. This course builds the foundation for geometry and theoretical physics courses.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand differentiable maps on manifolds, tangent vectors and tangent space, cotangent space, vector fields, Lie-bracket of vector fields, immersions and embeddings.
- Understand tensors and forms, exterior product and Grassman algebra, connections, difference tensor, existence of parallelism and geodesics, covariant derivative, exterior derivative contraction, Lie-derivative.
- Understand torsion tensor and curvature tensor of a connection, properties of torsion and curvature tensor.
- Understand Riemannian manifolds fundamental theorem of Riemannian geometry, Riemannian connection, Riemannian curvature tensor and its properties.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Differentiable Manifolds, examples of differentiable manifolds, local coordinate approach, Differentiable maps on manifolds, tangent vectors and tangent space, different approaches to tangent

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

vector, cotangent spaces, Vector Fields, Lie-bracket of vector fields, Jacobian map, pull back maps, integral curves, Tensors Exterior product, forms, exterior derivative, contraction, Lie-derivative. Difference tensor, difference tensor, covariant derivative of tensors,

SECTION-B

Torsion tensor and curvature tensor of a connection, properties of torsion and curvature tensor, Bianchi's identities, Riemann Metric, Riemannian manifolds, Fundamental theorem of Riemannian geometry, Riemannian connection. Riemannian curvature tensor and its properties. Bianchi's identities, Sectional curvature, Schur theorem, Sub-manifolds and hyper-surfaces.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Hicks, N. J.: Notes on Differential Geometry (Relevant Portion), Van Nostrang Reinhold company, 2nd Edition, 1971.
2. U.C. De: Differential Geometry Manifolds, Alpha Science Int. Ltd. Oxford U.K., 2007
3. B. B. Sinha: An introduction to modern Differential Geometry, Kalyani, New Delhi, 1982.
4. Y. Matsushima: Differentiable, 1stEdition, 1981.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT 304: CATEGORY THEORY-I

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course Objective: The objective of the course is to introduce the modern way of looking at the mathematical objects and their universal properties with the help of Categories, Functors and Natural Transformations. The student after completing the course will be ready to tackle the more advance methods of adjunctions and monads.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Students will develop a thorough understanding of the basic concepts and methods of category theory.
- They will be able to work with commutative diagrams, naturality and universality properties.
- Able to apply categorical ideas and methods in a wide range of areas of mathematics.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION – A

Categories: Introduction with Functions of Sets, Definition and examples of Categories: Sets, Pos, Rel, Mon, Groups, Top, Dis (X), Finite Category, The category of modules, The concept of functor and the category Cat, Functors of several variables. Isomorphism. Constructions: Product of two categories, The Dual Category, The Arrow Category, The Slice and Co- Slice Category. The Category of Graphs. Free Monoids and their UMP.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Abstract Structures**:** Epis and mono, Initial and Terminal objects, generalized elements, Sections and Retractions, Product diagrams and their Universal Mapping Property, Uniqueness up to isomorphism, Examples of products: Hom-Sets, Covariant representable functors, Functors preserving binary product.

SECTION –B

Duality: The duality principle, Coproducts, Examples in Sets, Mon, Top, Coproduct of monoids, of Abelian Groups and Coproduct in the category of Abelian Groups. Equalizers, Equalizers as a monic, Coequalizers, Coequalizers as an epic. Coequalizer diagram for a monoid.

Limits and Co-limits**:** Subobjects, Pullbacks, Properties of Pullbacks, Pullback as a functor, Limits, Cone to a diagram, limit for a diagram, Co-cones and Colimits. Preservation of limits, contra variant functors. Direct limit of groups. Functors Creating limits and co-limits.

Naturality: Exponential in a category, Cartesian Closed categories, Category of Categories, Representable Structure, Stone Duality, ultrafilters in Boolean Algebra, Naturality, Examples of natural transformations.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Steven Awodey: Category Theory, (Oxford Logic Guides, 49, Oxford University Press.) Chapter 1 to 3 Excluding Example 6 of Sec 2.6 and Chapter 5 and Sections 6.1, 6.2 and Chapter 7; Sections 7.1 to 7.5), 2nd Ed., 2010.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT305: ADVANCED COMPLEX ANALYSIS

L T P Duration: 60 Hours

5 1 0 External Evaluation: 70

Pass percentage: 35% Internal Assessments: 30

External Examination Time: 3 hours.

Course objectives: The main aim is to make students familiar with Zeros of Analytic Functions, Riemann Surfaces for Multi Valued Functions, their Construction for the Complex Logarithm and m^{th} root function it is expected that on successful completion of this course the students will be able to understand the concept of Analytic Continuation and Harmonic function.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Derive the theorems related to zeros of analytic function.
- Construct Riemann surfaces for complex logarithmic and m^{th} root function.
- Understand the concept of Analytic continuous function.
- Classify weather the function is Harmonic continuous

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Fundamental Theorems Connected with Zeros of Analytic Functions. The Argument (Counting) Principle, Rouche's Theorem and The Fundamental Theorem of Algebra, Morera's Theorem and Normal Limits of Analytic Functions, Hurwitz's Theorem and Normal Limits of Univalent Functions, The Open Mapping Theorem, Inverse Function Theorem, The Integral Inversion Formula for the Inverse Univalent Analytic Functions have never-zero Derivatives and are Analytic Isomorphisms Implicit Function Theorem, The Integral Formula for & Analyticity of the Explicit Function, Riemann

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Surfaces for Multi-valued Functions, Constructing the Riemann Surface for the Complex Logarithm. Constructing the Riemann Surface for the m-th root function, The Riemann Surface for the functional inverse of an analytic mapping at a critical point, the Algebraic nature of the functional inverses of an analytic mapping at a critical point.

SECTION B

Analytic Continuation: Direct Analytic Continuation or an Analytic Extension, General or Indirect Analytic Continuation and the Lipschitz Nature of the Radius of Convergence, Analytic Continuation Along Paths via Power Series, Analytic Continuation Along Paths via Power Series, Continuity of Coefficients occurring in Families of Power Series defining Analytic Continuations along Paths, Monodromy Goals, Analytic Continuabilityalong Paths, Dependence on the Initial Function and on the Path - First Version of the Monodromy Theorem , Maximal Domains of Direct and Indirect Analytic Continuation, Second Version of the Monodromy Theorem, Deducing the Second (Simply Connected) Version of the Monodromy Theorem from the First (Homotopy) Version, Existence and Uniqueness of Analytic Continuations on Nearby Paths.

Harmonic Functions, Maximum Principles, Schwarz's Lemma and Uniqueness of Riemann Mappings, The Mean-Value Property, Harmonic Functions and the Maximum Principle.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. S. Ponnuswamy: Foundations of Complex Analysis, Narosa Publishing House, 2011.
2. T. W. Gamelin: Complex Analysis, Springer, 2001.
3. E. T. Copson: Theory of Functions of a Complex Variable (Oxford University Press).

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT306: TOPOLOGY-II

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course Objectives: This course is an extension of topology-I. Continuing with the study of regular normal, quotient spaces and their properties. Students will learn Product of spaces, Filters, adjunction spaces and will be able to apply their knowledge to other fields.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Define and illustrate the concepts of the separation axioms.
- Understand the concept of Nets and Filters, their relation and prove the related theorems.
- Define and understand identification topology, quotient spaces and prove the theorem related to the topic.
- Understand the concept of cones, suspensions, and week topology and adjunction spaces.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

One-point Compactification, T_0, T_1, and T_2 spaces, T_2 spaces and Sequences and Hausdorfness of One-Point Compactification.

Axiom of countability and separability, equivalence of second axiom, separable and lindelof in metric spaces, equivalence of compact and countably compact sets in metric spaces.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Higher Separation Axioms: Regular, Completely Regular, Normal and Completely Normal Spaces. Metric Spaces as Completely Normal T_2 Spaces. Urysohns Lemma and the Tietze Extension Theorem. Point finite and Locally Finite families, Covering Characterization of Normality, Urysohn's Metrization Theorem.

SECTION –B

Filters, Ultra Filter, Filter Characterization of Compactness and The Tychonoff Theorem Identification Topology: Identification Topology, Identification Map, Subspaces, General Theorem, Transgression, Transitivity Spaces with Equivalence Relation, Quotient Spaces. Cones and Suspensions, Attaching of Spaces, Adjunction Space, The relation K(f) for continuous maps and Weak Topologies.

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

RECOMMENDED AND SUGGESTED READINGS(R&S)

1. W.J. Pervin: Foundations of General Topology Section Ch 5 Sec 5.1,5.2 ,5.3, 5.5 to 5.6.
2. Stephen Willard: GENERAL TOPOLOGY Ch4(12.1-12.14), Ch6(Theorem 17.8 only)
3. James Dugundji: TOPOLOGY. Chapter VI, VII (1.3(3),2.3(2),3.3(3),6.1,7.2to 7.4 only and theorem 8.2 of Chapter XI).
4. James Munkers: Topology, 2nd Ed., Printice Hall, Indian Learning Pvt. Ltd.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT307: NON-PARAMETRIC INFERENCE

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: The objective of this course is to apprise the students about various techniques of hypothesis testing when the assumptions of parametric set up are not fulfilled. Thrust will be to study various non-parametric analogues to one, two and c-sample location problems as well as two sample scale problem.

Course Learning Outcomes: Upon completion of this course:

- The students will learn applying various non-parametric and sequential estimation and testing procedures to deal with the real-life problems.
- Students will be able to learn non-parametric methods.
- Students will also be able to learn U-statistics and UMVU estimators.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION –A

Estimable parametric functions, kernel, symmetric kernel, one sample U-Statistic. Two sample U-Statistic, asymptotic distribution of U-Statistics, UMVUE property of U-Statistics. Empirical distribution function, confidence intervals based on order statistics for quantiles, tolerance regions. Tests for randomness: Tests based on the total number of runs and runs up and down. Rank-order

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

statistics. One sample and paired-sample techniques: sign test and signed-rank test. Goodness of fit problem: Chi-square and Kolmogorov-Smirnov tests.

SECTION - B

The General Two Sample Problem: Two sample stochastic dominance problem, stochastic modeling of two sample location and scale problems in nonparametric setting. Wald Wolfwilzrun test and Kolmogorov –Smirnov two sample test. Linear Rank Statistics: Linear Rank Statistics and its limiting distribution, Rank test, MP and LMP rank tests. Tests for two-sample location problem: Wilcoxon-Mann-Whitney, Terry-Hoeffding, Van der Waerden, Median tests. Tests for two-sample scale problem: Mood Test, Tests for the c-sample problem: Kruskal-Wallis test.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. V.K. Rohtagi: Staistical Inference, Dover Books on Mathematics, 2003

2.T.R. Jain and S.C. Aggarwal: Business Statistics, 2014

3.V.K. Rohtagi and A.K. Ehsans Sakhy: An Introduction to Probability and Statistics, Wiley Series 2000.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT308: ANALYTIC NUMBER THEORY

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course Objectives: The main objective to study the number theory is to understand the concepts of Divisibility, Arithmetical functions, Averages of arithmetical functions, some elementary theorems on the distribution of prime numbers and Dirichlet characters.

Course Learning Outcomes: The course will enable the students to

- Learn about the arithmetical functions.
- Know about the elementary properties of groups.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION -A

Arithmetical functions: Mobius function, Euler's totient function, Mangoldt function, Liouville's function, the divisor functions, Relation connecting φ and μ, product formula for $\varphi(n)$, Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, Multiplicative functions, Dirichlet multiplication, the inverse of a completely multiplicative function, Generalized convolutions.

Averages of arithmetical functions: The big oh notation, Asymptotic equality of functions, Euler's summation formula, Elementary asymptotic formulas, Average order of $d(n)$, $\varphi(n)$,$\sigma_\alpha(n)$, $\mu(n)$, $\Lambda n)$, The Partial sums of a Dirichlet product, applications to $\mu(n)$ and $\Lambda(n)$, Legendre's identity.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION -B

Some elementary theorems on the distribution of prime numbers: 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, 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, Characters of finite abelian groups, The character group, Orthogonality relations for characters, Dirichlet characters, Dirichlet's theorem for primes of the form 4n-1 and 4n+1, Dirichlet's theorem in primes on Arithmetical progression, Distribution of primes in Arithmetical progression.

RECOMMENDED ANDSUGGESTED BOOK(R&S):

1. T.M. Apostol : Introduction to Analytic Number Theory

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SYLLABUS

M.Sc. Mathematics (Part-II)

Session 2023-2024(Semester –IV)

Course Code	Course Name	Credits L T P	External Marks	Internal Marks	Total Marks
Core course MSMAT 401	THEORY OF LINEAR OPERATORS	5 1 0 (6)	70	30	100
Core Course MSMAT402	MATHEMATICAL METHODS	5 1 0 (6)	70	30	100
CHOOSE ANY THREE OF THE FOLLOWING ELECTIVE COURSES					
Elective Course MSMAT403	LIE GROUPS AND COMPLEX MANIFOLDS	5 1 0 (6)	70	30	100
Elective Course MSMAT 404	FLUID MECHANICS	5 1 0 (6)	70	30	100
Elective Course MSMAT 405	ALGEBRAIC CODING THEORY	5 1 0 (6)	70	30	100

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

Elective Course MSMAT 406	OPERATIONS RESEARCH	5 1 0 (6)	70	30	100
Elective Course MSMAT 407	NON- LINEAR PROGRAMMING	5 1 0 (6)	70	30	100
Elective Course MSMAT 408	NUMERICAL SOLUTION OF ODE & PDE	5 1 0 (6)	70	30	100
Elective Course MSMAT409	ALGEBRAIC TOPOLOGY	5 1 0 (6)	70	30	100
Elective Course MSMAT410	FIELD THEORY	5 1 0 (6)	70	30	100
Elective Course MSMAT411	CATEGORY THEORY-II (Pre Requisite: **CATEGORY THEORY-I)**	5 1 0 (6)	70	30	100
Total		30			500

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE

MSMAT401: -THEORY OF LINEAR OPERATORS

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: The objective of this subject is to introduce students to understand the importance of linear Operator theory, Spectral theory in normed linear spaces, Spectral properties of compact linear operators on normed space.

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

- Understand spectrum of linear operators on normed linear spaces and spectrum of linear operators.
- Understand spectrum of Elementary theory of Banach algebras and compact operators.
- Spectral properties of compact linear operators on normed space.
- Spectral properties of bounded self-adjoint linear operators on a complex Hilbert space.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Spectral theory in normed linear spaces, resolvent set and spectrum. Spectral properties of bounded linear operator. Properties of resolvent and spectrum. Spectral mapping theorem for polynomials, spectral radius of bounded linear operator on a complex Banach space.

Elementary theory of Banach algebras. Resolvent set and spectrum. Invertible elements, Resolvent equation. General properties of compact linear operators.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-B

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.

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.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. E. Kreyszig: Introductory Functional Analysis with Applications, Wiley Publications, 2011.

2. G. Bachman and L. Narici: Functional Analysis, Dover Publications, 1966.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

CORE COURSE
MSMAT 402: MATHEMATICAL METHODS

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: This course is intended to prepare the student with mathematical tools and techniques that are required in advanced courses offered in the applied mathematics and engineering programs. The objective of this course is to enable students to apply transforms and variation problem technique for solving differential equations and extremum problems.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand linear integral equations of first and second kind and solutions of these equations. Abel's problem.
- Understand Volterra's solution of Fredholm's equation. Hadamard's theorem, convergence proof, Fredholm's two fundamental relations. Fredholm's solution of integral equation when $D(\lambda)\neq 0$. lemmas on iterations of symmetric kernel.
- Solve simple variational problems, necessary condition for an extremum, Euler's equation. Solve end point problem, variational derivative, Invariance of Euler's equation.
- Solve fixed end point problem for n-unknown functions, Variational problem in parametric form, functionals depending on higher order derivatives.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION –A

Linear integral equations of first and second kind, Abel's problem, Relation between linear differential equation and Volterra's equation, Non-linear and Singular equations, Solution by successive substitutions and successive approximations, Volterra's equation, iterated and reciprocal functions, Volterra's solution of Fredholm's equation. Fredholm's equation as limit of finite system of linear equations, Hadamard's theorem, convergence proof, Fredholm's two fundamental relations, Fredholm's solution of integral equation when $D(\lambda)\neq 0$, Fredholm's solution of Dirichlet's problem and Neumann's problem, Lemmas on iterations of symmetric kernel, Schwarz's inequality and its applications. (Scope as in the R&S-I)

SECTION – B

Simple variational problems, Necessary condition for an extremum, Euler's equation, End point problem, Variational derivative, Invariance of Euler's equation, Fixed end point problem for n-unknown functions, Variational problem in parametric form, Functionals depending on higher order derivatives. Euler Lagrange equation, first integral of Euler-Lagrange equation, Geodesics, The Brachistochrone. Minimum surface of revolution, Brachistochrone from a given curve to a fixed point.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. W.V. Lovitt: Linear Integral Equations, Dover Publications, New York, 1924.
2. F. B. Hildebrand: Method of Applied Mathematics. Prentice Hall, India.
3. I. M. Gelfand& S.V. Fomin: Calculus of Variations, Prentice Hall, India, 1963.
4. Robert Weinstock: Calculus of Variations, Dover Publications, Revised Edition, 2012.
5. L. G. Chambers: Integral Equations, International Text Book Co., 1976.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT 403: LIE GROUPS AND COMPLEX MANIFOLDS

L T P Duration: 60 Hours

5 1 0 External Evaluation: 70

Pass percentage: 35% Internal Assessments: 30

External Examination Time: 3 hours.

Course objectives: This course is an advanced course in manifolds. The course starts with a topological group, Lie groups, Lie algebra and it is followed by bundle, Bundle homomorphism. Sub-manifolds, Normals, Gauss formulae, Weingarten equations, Lines of curvature, Generalized Gauss and Mainardi–Codazzi equations. Almost Complex manifolds, Nijenhuis tensor, Contravariant and covariant almost analytic vector fields, F-connection.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand topological groups, Lie groups and lie algebras, homomorphism and isomorphism, Lie transformation groups, general linear groups**.**
- Learn the concept of Principal fiber bundle, linear frame bundle, associated fiber bundle, Vector bundle, Tangent bundle, Induced bundle, Bundle homomorphism.
- Learn the concept of normals, Gauss formulae, Weingarten equations, Lines of curvature, Generalized Gauss and Mainardi–Codazzi equations.
- Learn the concept of Nijenhuis tensor, Contravariant and covariant almost analytic vector fields, F-connection.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-A

Topological groups, Lie groups and lie algebras. Product of two Liegroups, One parameter subgroups and exponential maps. Examples of Lie groups, Homomorphism and Isomorphism, Lie transformation groups, General Linear groups, submanifolds, induced connections and the associated second fundamental form, curvature tensor field of a submanifold, the normal vector along with the linear connections, the Gauss and Weingarten formula Gauss and Mainardi–Codazzi equations

SECTION – B

Almost Complex manifolds, Nijenhuis tensor, Contravariant and covariant almost analytic vector fields, F-connection, Hermitian metric, almost Hermitian manifold, Linear connections in almost Hermitian manifold, Hermitian manifold with their characterization, the Fundamental 2-form phi, Kaehlerian metric, Almost Kaehler manifolds, Kaehler manifolds, constant holomorphic sectional curvature, complex space forms.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Nomizu and Kobayashi: Foundation of Differential Geometry

2 U.C De and A.A. Shaikh: complex Manifold and contact manifold, Narosa Publishing House.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT 404: FLUID MECHANICS

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: This course is intended to provide a treatment of topics in fluid mechanics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems. The objective is to provide the student with knowledge of the fundamentals of fluid mechanics and an appreciation of the applications to real-world problems.

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

- Understand equations of fluid mechanics, Bernoulli's theorem steady irrotational non-viscous compressible flow.
- Solve three dimensional sources and dipoles, spherical obstacle in a uniform steam Moving sphere, images.
- Understand the application of complex variable method, two-dimensional dipole, superposition, Joukowski's transformation. Milne Thomson circle theorem, Blasius theorem, drag and lift.
- Understand Diffusion of vorticity in an incompressible fluid steady flow through a straight circular pipe.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-A

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. Three dimensional problems: Laplace's equation. Three dimensional sources and dipoles. Spherical obstacle in a uniform steam Moving sphere, images.

SECTION-B

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.

Source and vortex filaments, vortex pair, rows of vortices, Karman cortex street. 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).

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. D. E. Rutherford: Fluid Dynamics, Oliver & Boyd Ltd, 1st Edition, 1959
2. F. Chorlton: Fluid Dynamics, (Relevant portion) Cambridge University Press, 1st Edition, 1985.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT405: ALGEBRAIC CODING THEORY

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: The objective of the course is to introduce basic topics of algebraic coding theory like error correction and detection, linear codes, ISBN Codes, teach students to change New Codes from old, learn the concept of Reed-Muller codes and Linear Programming bounds.
Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand the concept of Maximum-Likelihood Decoding and Syndrome Decoding.
- Analyze Double Error-Correcting B.C.H. code and Finite Fields Polynomials.
- Understand Cyclic Codes and the concept of different kind of Codes
- Learn the concept of Linear Programming bounds.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Error detecting and error correcting codes, maximum likelihood decoding, Hamming distance, Finite Fields, Minimal polynomials, Linear Codes, Encoding with a Linear code, Generator matrix and parity check matrix, Dual Codes, Syndrome Decoding,

SECTION-B

ISBN Codes, New Codes from old, Sphere covering bound, Sphere packing bound, Gilbert

Varshamov bound, perfect codes, Hamming Codes, Golay codes, Simplex Codes, Singleton bound and MDS codes, Plotkin bound, Griesmer bound, Reed-Muller codes, Linear Programming bounds.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Raymond Hill: A first course in coding theory, 1st Edition, 1997.

2. F. J. Macwilliams& N. J. A Sloane: Theory of Error Correcting Codes, North Hollan Mathematical Library, 1st Edition, 1977.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

ELECTIVE COURSE

MSMAT 406: OPERATIONS RESEARCH

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: Operations research helps in solving problems in different environments that need decisions. This module aims to introduce students to use quantitative methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand and develop Poisson Queueing models.
- Understand deterministic and stochastic Inventory models.
- Understand the concept of Replacement and maintenance.
- Do optimal scheduling by CPM and Project Evaluation and Review Techniques (PERT).

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Queueing problems: Characteristics of queueing system. Distributions in queueing systems, Poisson arrivals and exponential service times, the M/M/I, M/M/S queueing systems, steady state solutions and their measures of effectiveness.

Inventory problems, definition, the nature and structure of inventory system, deterministic models and their solution, multi-item inventory problems, stochastic inventory models.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

SECTION-B

Replacement and maintenance problems: replacement of capital equipment, discounting cost, replacement in anticipation of failure, preventive maintenance.

Network Analysis: Introduction to Networks, Minimal Spanning Tree Problem, Shortest Path problem: Dijkstra's Algorithm, Floyd's Algorithm, Maximum Flow Problem, Project Management: Critical Path method, Critical Path Computations, Optimal Scheduling by CPM, Project Evaluation and Review Techniques (PERT)

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. S.D. Sharma: Operation research, KedarNath and Co., Meerut, 2008.
2. K. Swaroop, P.K. Gupta and Man Mohan: Operations Research, Sultan Chand and Sons, 2004.
3. Hamdy A. Taha: Operations Research; An Introduction, PHI, New Delhi, 10th Edition, 2017.
4. Kasana and Kumar: Introductory Operation Research, Springer, 1st Edition, 2004.
5. Chander Mohan and Kusum Deep: Optimization Techniques, New Age International, 1st Edition, 2009.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

ELECTIVE COURSE

MSMAT407: NON-LINEAR PROGRAMMING

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: To acquaint the students with the concepts of convex and non-convex functions, their properties, various optimality results, techniques to solve nonlinear optimization problems and their duals over convex and non-convex domains and also with the game theory.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Learn the basic concepts of nonlinear programming and solve problems of minima and maxima of convex and concave functions.
- Solve programming problems with inequality constraints.
- Solve quadratic programming problems and learn various methods.
- Understand and solve linear and nonlinear fractional problems.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION –A

Nonlinear Programming: convex function, definition and basic properties, sub gradients of convex function, differentiable convex function, minima and maxima of convex function and concave function. Generalization of convex function and their properties, unconstrained problems, necessary and sufficient optimality criteria of first and second order. Fritz John and Kuhn Tucker first order necessary and sufficient optimality conditions for constrained

programming problems with inequality constraints, with inequality and equality constraints, Kuhn Tucker conditions and linear programming problems.

SECTION –B

Quadratic Programming, methods due to Wolfe. Wolfe's duality in nonlinear programming, weak duality theorem, Wolfe's duality theorem, Hanson-Huard strict converse duality theorem (without proof), Dorn's duality theorem, strict converse duality theorem, Dorn's convers duality theorem(without proof).Unbounded dual theorem, theorem on no primal minimum, duality in quadratic programming, Linear and nonlinear fractional programming, Dinkelbeach's algorithm.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. O. L. Mangasarian: Nonlinear Programming, TATA McGraw Hill Company Ltd (Bombay, New Delhi), 2006.
2. Bazaraa, M.S., Sherali, Hanif D and Shetty, C.M., Nonlinear programming: Theory and Algorithm, John Wiley, Second Edition, 1993.
3.S.M Sinha: Mathematical Programming, Theory and methods, Elsevier, 1st Edition, 2006.

4. H.A Taha: Operation Research- An Introduction, McMillan Publishing Co. Inc. New York.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

ELECTIVE COURSE

MSMAT 408: NUMERICAL SOLUTION OF ODE & PDE

L T P Duration: 60 Hours

5 1 0 External Evaluation: 70

Pass percentage: 35% Internal Assessments: 30

External Examination Time: 3 hours.

Course objectives: The objective of this course is to provide the knowledge of numerical solutions of ordinary and partial differential equations. This course introduces the finite difference techniques for solving Parabolic, elliptic and hyperbolic partial differential equations.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understand and solve parabolic Equation, Elliptic Equation, Finite difference replacement and reduction to block tridiagonal form and its solution.
- Find Solution by Gauss-Seidel, Gaussian elimination and SOR Method, treatment of curved boundaries.
- Find solution by alternate direction implicit method.
- Solve hyperbolic equations and understand and use approximate methods**.**

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

Ordinary Differential Equations: Taylor's series, Euler's method, Modified Euler's method, and Runge-Kutta methods (upto fourth order), Consistency, Stability and convergence of Euler,

Modified Euler's & Runge-Kutta Methods and Predictor Corrector Methods (Adam Bashforth and Milne's Method). Stability analysis of Predictor Corrector Methods. Parabolic Equation: Dirichlet and Neumann boundary conditions, Explicit, Fully Implicit, Crank-Nicolson, Richardson's Explicit and Du fort & Frankel finite difference schemes for one dimensional parabolic equations. Discussion of their compatibility, stability and convergence.

SECTION-B

Peaceman-Rachford A.D.I. scheme for two dimensional parabolic equations. Elliptic Equation: Finite difference replacement and reduction to block tri-diagonal form and its solution, Treatment of curved boundaries solution by Gaussian elimination, Gauss-Jacobi, Gauss-Seidel and SOR Method.

Hyperbolic equations in one dimension: Explicit, Implicit, Upwind and Lax-Wendroff Schemes on rectangular grids and their stability, Solution by finite difference methods on characteristics grids.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. R.S. Gupta: Elements of Numerical Analysis, Cambridge University, 2015
2. G.D. Smith: Numerical solution of partial differential equations, Oxford Univ. Press, 3rd Edition, 1986.
3. K.W. Moton and D.F. Mayers, Numerical Solution of Partial Differential Equations, 2nd Edition, Cambridge Press, 2005.
4. A. R. Mitchell: Computational methods in partial differential equations, John Wiley, 1975.
5. C. E. Froberg: Introduction to Numerical Analysis, Addition-Wesley Reading Mass, 1969.
6. C.F. Gerald: Applied Numerical Analysis, Addition Wesley, Reading, Mass, 1970.
7. M. K. Jain: Numerical solutions of Differential equations, John Wiley, 1984.
8. L. Collatz.: Numerical Treatment of Differential Equations, Springer - Verlag, Berlin, 1966.

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

ELECTIVE COURSE

MSMAT409: ALGEBRAIC TOPOLOGY

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: To acquaint the students with the concepts of convex and non-convex functions, their properties, various optimality results, techniques to solve nonlinear optimization problems and their duals over convex and non-convex domains and also with the game theory.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- To be familiar with the Fundamental group, Topological invariance, covering spaces, The Fundamental group of the circle. Retractions and fixed points and the Fundamental theorem of Algebra,
- To understand direct sums of abelian groups, Free products of groups, their generators and relations, The Seifert-Van Kampen theorem and the Fundamental group of a wedge of circles.
- To be able to do Classification of covering spaces.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION-A

The Fundamental group: Homotopy of paths, Homotopy classes, The Fundamental group, change of base point, Topological invariance, covering spaces, The Fundamental group of the

circle. Retractions and fixed points, No Retraction Theorem, The Fundamental theorem of Algebra, The Borsuk - Ulam theorem, The Bisection theorem, Deformation Retracts and Homotopy type, Homotopy invariance.

SECTION – B

Direct sums of Abelian Groups, Free products of groups, uniqueness of free products, least normal subgroup, free groups, generators and relations, The Seifert-Van Kampen theorem, also classical version, The Fundamental group of a wedge of circles. Classification of covering spaces: Equivalence of covering spaces, the general lifting lemma, the universal covering space, covering transformation, existence of covering spaces.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. James R. Munkres: Topology, Pearson Prentice Hall, Chapter – 9(51-58), Chapter –11(67-71), Chapter - 13 (79-82).

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

ELECTIVE COURSE

MSMAT 410: FIELD THEORY

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course objectives: To look in detail at the theory of fields as applied to one of the earliest motivational problems of algebra, solving polynomial equations. To develop one of the most beautiful gems of mathematics, the Galois Theory of polynomial equations, to the extent that we can answer and understand why is there no general formula giving the roots of a general polynomial of degree five or higher, in terms of its coefficients using only the basic algebraic operations of addition, subtraction, multiplication, division and forming radicals – that is, square roots, cube roots etc.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- Understanding of basic concepts of Fields, Algebraic and transcendental elements, irreducible polynomials. Gauss Lemma, Eisenstein's criterion.
- Find the Adjunction of roots, Kronecker's theorem, algebraic extensions, algebraically closed fields. Splitting fields, Normal extensions, multiple roots, finite fields, Separable extensions, perfect fields, primitive elements, and Lagrange's theorem on primitive elements.
- Be familiar with automorphism groups and fixed fields, Galois extensions, Fundamental theorem of Galois theory, Fundamental theorem of algebra, Roots of unity and cyclotomic polynomials.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections: A, B and C. Sections A and B will have four questions each carrying 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short questions carrying 3 marks each covering the entire syllabus uniformly.

Ms. Namita Berry Dr. Shalini Gupta Prof. S.S. Dhaliwal Dr. Sapna Sharma Mr. Bharat Bhushan

Mr. Gurjeet Singh Ms. Poonam Chawla Ms. Shivdeep Kaur Mr. Sham Bansal Dr. Rajinder Pal

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION A

Fields, examples, Algebraic and transcendental elements, irreducible polynomials. Gauss Lemma, Eisenstein's criterion, Adjunction of roots, Kronecker's theorem, algebraic extensions, algebraically closed fields. Splitting fields, Normal extensions, multiple roots, finite fields, Separable extensions, perfect fields, primitive elements, and Lagrange's theorem on primitive elements.

SECTION -B

Automorphism groups and fixed fields, Galois extensions, Fundamental theorem of Galois Theory, Fundamental theorem of algebra, Roots of unity and cyclotomic polynomials. Cyclic extension, Polynomials solvable by radicals, Symmetric functions, cyclotomic extension, quantic equation and solvability by radicals.

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Bhattacharya, Jain & Nagpaul: Basic abstract algebra (Chapters 15-17 and 18: excluding section 5)
2. M. Artin: Algebra Prentice Hall Indian Private Limited, 2006

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.

ELECTIVE COURSE

MSMAT 411: CATEGORY THEORY-II
(Pre-Requisite **CATEGORY THEORY-I)**

L T P Duration: 60 Hours
5 1 0 External Evaluation: 70
Pass percentage: 35% Internal Assessments: 30
External Examination Time: 3 hours.

Course Objective: This course continues the study of Category Theory and achieves the aim of the study of Adjunctions and Monads. The famous Yoneda Lemma finds numerous applications in the course.

Course Learning Outcomes: Upon completion of this course, students should be able to:

- To develop a thorough understanding of the advanced concepts and methods of category theory.
- They will be able to work with Functor Categories, Equivalence, Category of diagrams, Adjoints, Monads and Algebras.
- Able to apply categorical ideas and methods in a wide range of areas of mathematics.

INSTRUCTIONS FOR THE PAPER-SETTER

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

INSTRUCTIONS FOR THE CANDIDATES

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

SECTION- A

Equivalence: The functor category Fun (C, D) and natural isomorphism. (R.R: Sections 6.1, 6.2 and 7.1 to 7.5) Equivalence: Exponentials of Categories, The Bifunctor Lemma, Cat is Cartesian closed, Functor Categories, Equivalence of Categories, Examples of Equivalence: Setsfin and

Ordfin., Pointed Set and partial maps, slice categories and indexed families, stone duality. (R&S7.6 to 7.9)

Categories of Diagrams**:** Set-valued functor categories, The Yoneda embedding, The Yoneda Lemma, Applications of the Yoneda lemma, Limits, Colimits and Exponentials in Categories of diagrams. Hom (X, GP) and Hom (X x P , Q) . (R&S.: Sections 8.1 to 8.7)

SECTION- B

Adjoints: Adjunction between categories, left and right adjoints, Hom-Set definition of adjoints. Examples of Adjoints, Uniqueness up to isomorphism. Order Adjoints and interior operation in Topology as an order adjoint. Preservation of Limits (Co limits) by Right (Left) Adjoints. UMP of the Yoneda Embedding and Kan Extensions. The Adjoint Functor Theorem.

Monads and Algebras: The Triangle Identities, Monads and Adjoints, Algebras for a monad, The Elinberg- Moore Category and the Kliesli Category, Comonads and Colagebras. (R & S Chapter 9; Sections 9.1 to 9.4, 9.6 AFT from Sec 9.8 and Chapter 10; Sections 10.1 to 10.4)

RECOMMENDED AND SUGGESTED READINGS(R&S):

1. Steve Awodey: Category Theory, (Oxford Logic Guides, 49, Oxford University Press.)

Teaching Learning Activities:

Assignments: Class assignments focus on strong foundation of conceptual knowledge, better understanding of the subject and development of problem-solving skills.

Guest lectures: Guest lectures are conducted for overall development of students and strong foundation of subject

Quizzes: Quizzes are organized to build the bridge between theoretical (conceptual knowledge) and practical applications of the learned concepts.

Group Discussion: Group discussions are conducted to develop and boost the self-confidence, competitive aptitude and enhance the problem-solving skills.

Seminars: Seminars are conducted for overall personality development, to prepare them for interviews and class teaching. This will help them in further placement.