Scheme / Structure of M.Sc Mathematics
CBCS course for Department of Mathematics, K.U.K

Course Name	**:**	Master of Science in Mathematics CBCS course for Department of Mathematics, KUK
Course Duration	**:**	Four Semesters
Course Code	**:**	MSM
To be effective	**:**	With effect from Session **2016-17** for **1st and 2nd Semesters** and from **2017-18** for **3rd and 4th Semesters** in the Department of Mathematics, K.U. Kurukshetra

General Rules :

1. There will be five theory papers and one practical paper in each semester. In addition, there will be two seminars, one each in 1st semester and 4th semester and two open elective papers, one each in 2nd and 3rd semesters.

2. A student of M.Sc Mathematics CBCS course shall have to opt one Open Elective Paper in second semester and one Open Elective Paper in third semester out of the list of Open Elective Papers offered at the level of Faculty of Sciences except those which are offered as Open Elective Papers by the Department of Mathematics.

3. Open elective paper will be opted by a student out of the list of open elective papers which will be offered at the Faculty of Science level in that Semester.

4. Each theory paper (Core and Elective) will be of 100 marks, 70 marks for External Examination and 30 marks for Internal Assessment.

5. Each practical paper and open elective paper will be of 50 marks, 35 marks for External Examination and 15 marks for Internal Assessment.

6. Each seminar will be of 50 marks. The evaluation of seminars, which will be presented by every student in that semester, will be done by a Departmental Committee which will be constituted by the Staff Council of the Department and marks shall be awarded by the committee out of 50 marks. There shall be no external examination of the seminar.

7. Each theory paper will consist of two sections.

8. Paper setter will be requested to set eight questions in all, i.e., four questions from each section.

9. The examinee will be required to attempt five questions in all by selecting at least two questions from each section. All questions will be of equal marks.

10. Duration of examination of each theory paper will be of three hours and duration of examination of each practical paper will be of four hours.

11. The minimum pass percentage required to pass each paper will be as under:
    1. 40% in each theory (C/E/OE) External Examination
    2. 40% in each Practical External Examination
    3. 40% in each Seminar
    4. 40% in aggregate of External Examination and Internal Assessment Test of each theory (C/E/OE) and Practical Paper.

12. The following criteria shall be adopted for the award of Internal Assessment for each paper:

i. Theory papers: -

a. Sessional test (1 hour duration)	:	15 marks
b. Class test (1 period)	:	10 marks
c. Attendance	:	05 marks

ii. Practical papers: -

a) Viva-voce	:	05 marks
b) Class test (1 period)	:	05 marks
c) Attendance	:	05 marks

iii. Open elective theory papers: -

a) Sessional test (1 hour duration)	:	05 marks
b) Class test (1 period)	:	05 marks
c) Attendance	:	05 marks

iv. Criterion for the award of marks for attendance will be as follows:

(a)	More than 90 %	: 5 Marks	(b)	more than 80% but up to 90%	: 4 Marks
(c)	75% to 80 %	: 3 Marks	(d)	70% to less than 75%	: 2 Marks*
			(e)	65% to less than 70%	: 1 Mark*

* For students engaged in co-curricular activities of the Department only / authenticated medical grounds duly approved by the concerned Chairperson.

v. For theory and practical papers, it will be optional for the department concerned to conduct either a viva-voce or a sessional test for each paper. The test of one hour duration for each paper will be conducted by the Department concerned at its own level on the dates, which should be announced at least 15 days before the commencement of the test.

vi. For theory and practical papers, one class (surprise) test of one period duration for each paper will be conducted by the teacher concerned at his/her own level, before the commencement of the semester examination.

vii. Internal assessment test/viva-voce is compulsory. In case the student(s) remain absent from appearing in the test(s)/viva-voce, the Chairperson of the Department concerned will decide the case at his/her own level.

viii. Internal assessment awards of the candidate who fails in any paper shall be carried forward to the reappear examination of that paper.

ix. The internal assessment marks obtained by the students will be displayed separately component-wise/point-wise and paper-wise on the notice board of the department, 15 days before the commencement of the semester examination so that the student(s) found absent from appearing in the previous test(s) may appear in a special test as the last chance. This chance may not be a regular feature.

x. Paper-wise consolidated marks obtained by the students in internal assessment, duly countersigned by Chairperson of the Department concerned shall be forwarded to the Examination Branch at least one week before the commencement of the relevant semester examination.

xi. The Chairperson of the Department concerned shall preserve the record on the basis of which the sessional/internal assessment awards have been prepared, for inspection, if needed by the University upto six months from the date of the declaration of the result of concerned semester.

13. One credit is equivalent to 25 marks.

14. Teaching hours : One credit is equivalent to one hour of teaching (lecture/ tutorial/seminar) per week per semester for each theory paper, One credit is equivalent to two hours of practical work per week per semester.

Theory papers (Core or Elective) : Four hours for lectures per week per paper

Practical paper	:	Four hours per week per paper for a group of fifteen students.
Seminar	:	Two hours per week for a group of fifteen students
Theory Papers (Open Elective)	:	Two hours per week per paper

15. Abbreviations used:

C	:	Core Paper
E	:	Elective Paper
OE	:	Open Elective Paper
L	:	Lecture
T	:	Tutorial
P	:	Practical
S	:	Seminar

LEARNING OBJECTIVES AND OUTCOMES OF DIFFERENT COURSES

SEMESTER – I

MSM 101: ABSTRACT ALGEBRA

The concept of a group is surely one of the central ideas of mathematics. The main aim of this course is to introduce Sylow theory and some of its applications to groups of smaller orders. An attempt has been made in this course to strike a balance between the different branches of group theory, abelian groups, nilpotent groups, finite groups , infinite groups and to stress the utility of the subject. A study of Modules, submodules, quotient modules, finitely generated modules etc. is also promised in this course. Hilbert basis theorem and Wedderburn -Artin theorem are the heighlights of this course.

MSM-102: COMPLEX ANALYSIS

One objective of this course is to develop the parts of the theory that are prominent in applications of the complex numbers. Other objective is to furnish an introduction to applications of residues and conformal mapping. With regard to residues, special emphasis is given to their use in evaluating real improper integrals, finding inverse Laplace transforms, and locating zeros of functions. Conformal mapping find its use in solving boundary value problems that arise in studies of heat conduction, fluid flow and elastodynamics.

MSM 103: ORDINARY DIFFERENTIAL EQUATIONS

This course has been framed to learn the theory of ordinary differential equations. Existence and uniqueness theory of solution of an ordinary differential equation and of an initial value problem is to be learnt during the course. Theory of homogeneous and non-homogeneous linear differential equations of higher order, Adjoint equations and Wronskian theory are also learnt during the course. Students will also learn second order ordinary differential equations and Sturm theory, Oscillation theory, boundary value problems and Greens functions in the context of such differential equations. On completion of the course, a student will be able to understand the theory of ordinary differential equations of 2nd and higher order and to know the techniques of solving them.

MSM 104: REAL ANALYSIS

This course has been developed to introduce some fundamental topics of mathematical analysis which are directly relevant in some other papers of M.Sc. Mathematics course. In this course the students will be taught Riemann Stieltjes integral, uniform convergence of sequences and series of functions, and functions of several variables.

MSM 105: TOPOLOGY

This course is a systematic exposition of the part of general topology which has proven useful in several branches of mathematics. Starting from the statements of Axiom of choice, Zorn's lemma, Well ordering theorem and Continnum hypothesis, we move on to the introduction of topological spaces and their properties. Some of the main topics taught in this course include Product and Quotient spaces, Embedding and Metrization, Compactness, Continuity and Filters.

MSM 106: PRACTICAL-I

This course is in continuation to the paper on numerical methods that students study during their graduate course. ANSI-C programming makes a part of that paper but students restrict themselves only to the theoretical knowledge. Hence, the objective of this course is to acquaint the students with the practical use of ANSI-C, for solving some problems of social and mathematical kind. Also some problem solving techniques based on papers MSM 101 to MSM 105 will be taught.

MSM 107: SEMINAR-I

In this course a student will learn to select the topic amongst syllabi of other courses prescribed in this semester. A student will learn to collect, review and to understand the literature and to present the contents of the topic so chosen. After the completion of this course the student will get an exposure towards self study and enhancement of presentation skills.

SEMESTER – II

MSM 201: ADVANCED ABSTRACT ALGEBRA

As suggested by the name of the course itself, some of the advanced topics of abstract algebra will be taught to the students in this course including field extensions, finite fields, normal extensions, finite normal extensions as splitting fields. A study of Galois extensions , Galois groups of polynomials, Galois radical extensions shall also be made. Similar linear transformations, Nilpotent transformations and related topics are also included in the course.

MSM 202: COMPUTER PROGRAMMING

This course is designed to train the students for complete knowledge of computer programming in FORTRTAN-90, along with the additional features of FORTRAN-95. The course enables the students to write any source program to compute the numerical solutions of the mathematics problems, which arise in the research studies with applications to engineering, physical, biological or social sciences.

MSM 203 : MEASURE AND INTEGRATION

One of the basic concepts of analysis is that of integration. The classical theory of integration has certain drawbacks: even relatively simple functions are not integrable in the Riemann sense. These deficiencies have been removed in the theory of Lebesgue measure and integration. This course aims at providing an introduction to the theory of Lebesgue measure and integration.The students will be taught Measurable Sets, Measurable functions, Lebesgue Integral, Differentiation and Integration and The Lebesgue L^p Spaces.

MSM 204: MECHANICS OF SOLIDS

In this course, basic theory of mechanics of solids is introduced. First, the laws of transformations and tensors will be introduced. Mathematical theory of deformations, analysis of strain and analysis of stress in elastic solids will be learnt next. A student will also learn basic equations of elasticity and variational methods. In this course, the students will be exposed to the mathematical theory of elasticity and other techniques which find applications in areas of civil and mechanical engineering and Earth and material sciences. After completion of this course, a student will get enough exposure to Applied Mathematics and this course will form a sound basis for doing research in the number of areas involving solid mechanics.

MSM 205: SYSTEM OF DIFFERENTIAL EQUATIONS

This course has been designed to understand system of differential equations including linear and non-linear systems. Initially, linear differential systems (homogeneous and non-homogeneous) and the existence and uniqueness theory for such systems are to be learnt and thereafter the theory is extended to system of n differential equations including non-linear systems. Characteristics and stability of critical points of non-linear systems and stability analysis of such non-linear systems would be studied during the course. After successful completion of this course, a student would be able to understand the theory of linear and non-linear differential systems and will also be able to do practical problems related to solutions of linear systems and related to critical points and stability of solutions of non-linear systems.

MSM 206: PRACTICAL-II

This course aims to train the students for practical implementations of all the features of FORTRAN-90, 95 programming, which they study as a theory course MSM 203, i.e., Computer Programming. Also some problem solving techniques based on papers MSM 201 to MSM 205 will be taught.

Scheme / Structure of M.Sc. Mathematics
CBCS Four Semester Course for Department of Mathematics, KUK
(w.e.f. Session 2016-17)

Semester - I

Paper Code	C /E /OE	Name of Paper	Contact hours			Credits
			L	P	S	
Core Papers						
MSM 101	**C**	Abstract Algebra	**4**	**0**	**0**	**4**
MSM 102	**C**	Complex Analysis	**4**	**0**	**0**	**4**
MSM 103	**C**	Ordinary Differential Equations	**4**	**0**	**0**	**4**
MSM 104	**C**	Real Analysis	**4**	**0**	**0**	**4**
MSM 105	**C**	Topology	**4**	**0**	**0**	**4**
MSM 106	**C**	Practical-I	**0**	**4**	**0**	**2**
MSM 107	**C**	Seminar-I	**0**	**0**	**2**	**2**
		Total	**20**	**4**	**2**	**24**

Semester - II

Paper Code	C /E /OE	Name of Paper	Contact hours			Credits
			L	P	S	
Core Papers						
MSM 201	**C**	Advanced Abstract Algebra	**4**	**0**	**0**	**4**
MSM 202	**C**	Computer Programming	**4**	**0**	**0**	**4**
MSM 203	**C**	Measure and Integration	**4**	**0**	**0**	**4**
MSM 204	**C**	Mechanics of Solids	**4**	**0**	**0**	**4**
MSM 205	**C**	System of Differential Equations	**4**	**0**	**0**	**4**
MSM 206	**C**	Practical-II	**0**	**4**	**0**	**2**
Open Elective Papers						
	OE	One open elective paper is to be opted out of the list of optional papers offered at the Faculty of Science level in even semester	**2**	**0**	**0**	**2**
		Total	**22**	**4**	**0**	**24**
OE 207		**Applied Algebra and Analysis** (This open elective paper will be offered to the students of Faculty of Sciences except students of Department of Mathematics)	**2**	**0**	**0**	**2**

Semester - III

Paper Code	C /E /OE	Name of Paper	Contact Hours			Credits
			L	P	S	
Core Papers						
MSM 301	C	Functional Analysis	4	0	0	4
MSM 302	C	Fluid Mechanics	4	0	0	4
MSM 303	C	Practical-III	0	4	0	2
Elective Papers		**Any three of the following Elective Papers**				
MSM 304	E	Advanced Topology	4	0	0	4
MSM 305	E	Algebraic Coding Theory	4	0	0	4
MSM 306	E	Commutative Algebra	4	0	0	4
MSM 307	E	Differential Geometry	4	0	0	4
MSM 308	E	Elasticity	4	0	0	4
MSM 309	E	Financial Mathematics	4	0	0	4
MSM 310	E	Fuzzy Sets and Applications	4	0	0	4
MSM 311	E	Integral Equations	4	0	0	4
MSM 312	E	Mathematical Modeling	4	0	0	4
MSM 313	E	Mathematical Statistics	4	0	0	4
MSM 314	E	Methods of Applied Mathematics	4	0	0	4
MSM 315	E	Number Theory	4	0	0	4
Open Elective Paper						
	OE	One open elective paper is to be opted out of the list of optional papers offered at the Faculty of Science Level in odd Semester	2	0	0	2
		Total	**22**	**4**	**0**	**24**
OE 307		**Applied Numerical Methods** (This open elective paper will be offered to the students of Faculty of Sciences except students of Department of Mathematics)	2	0	0	2

Semester - IV

Paper Code	C /E /OE	Name of Paper	Contact Hours			Credits
			L	P	S	
Core Papers						
MSM 401	C	Mechanics and Calculus of Variations	4	0	0	4
MSM 402	C	Partial Differential Equations	4	0	0	4
MSM 403	C	Practical – IV	0	4	0	2
MSM 404	C	Seminar-II	0	0	2	2
Elective Papers		**Any three of the following Elective Papers**				
MSM 405	E	Advanced Complex Analysis	4	0	0	4
MSM 406	E	Advanced Discrete Mathematics	4	0	0	4
MSM 407	E	Advanced Functional Analysis	4	0	0	4
MSM 408	E	Algebraic Number Theory	4	0	0	4
MSM 409	E	Analytic Number Theory	4	0	0	4
MSM 410	E	Bio-Mathematics	4	0	0	4
MSM 411	E	Boundary Value Problems	4	0	0	4
MSM 412	E	Fluid Dynamics	4	0	0	4
MSM 413	E	General Measure and Integration Theory	4	0	0	4
MSM 414	E	Linear Programming	4	0	0	4
MSM 415	E	Mathematical Aspects of Seismology	4	0	0	4
MSM 416	E	Non-Commutative Rings	4	0	0	4
MSM 417	E	Wavelet Analysis	4	0	0	4
		Total	**20**	**4**	**2**	**24**

SYLLABUS FOR M.SC MATHEMATICS SEMESTER – I

MSM-101: ABSTRACT ALGEBRA

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**
Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

Section-I (Four Questions)

Automorphisms and Inner automorphisms of a group G. The groups Aut(G) and Inn(G). Automorphism group of a cyclic group. Normalizer and Centralizer of a non-empty subset of a group G. Conjugate elements and conjugacy classes. Class equation of a finite group G and its applications. Derived group (or a commutator subgroup) of a group G. perfect groups. Simplicity of the Alternating group A_n ($n\geq5$). Zassenhaus's Lemma. Normal and Composition series of a group G. Scheier's refinement theorem. Jordan Holder theorem. Composition series of groups of order p^n and of finite Abelian groups. Caunchy theorem for finite groups. p-groups. Finite Abelian groups. Sylow p-subgroups. Sylow's Ist, IInd and IIIrd theorems. Application of Sylow theory to groups of smaller orders.

Commutators identities. Commutator subgroups. Three subgroups Lemma of P.Hall. Central series of a group G. Nilpotent groups. Centre of a nilpotent group. Subgroups and factor subgroups of nilpotent groups. Finite nilpotent groups. Upper and lower central series of a group G and their properties. Subgroups of finitely generated nilpotent groups. Sylow-subgroups of nilpotent groups. Solvable groups Derived series of a group G. Non-solvability of the symmetric group S_n and the Alternating group A_n ($n\geq5$). (Scope of the course as given in the book at Sr. No. 1).

Section-II (Four Questions)

Modules, submodules and quotient modules. Module generated by a non-empty subset of an R-module. Finitely generated modules and cyclic modules. Idempotents. Homomorphism of R-modules. Fundamental theorem of homomorphism of R-modules. Direct sum of modules. Endomorphism rings $End_Z(M)$ and $End_R(M)$ of a left R-module M. Simple modules and completely reducible modules (semi-simple modules). Finitely generated free modules. Rank of a finitely generated free module. Submodules of free modules of finite rank over a PID. Representation of linear mappings and their ranks.

Endomorphism ring of a finite direct sum of modules. Finitely generated modules. Ascending and descending chains of sub modules of an R-module. Ascending and Descending change conditions (A.C.C. and D.C.C.). Noetherian modules and Noetherian rings. Finitely co-generated modules. Artinian modules and Artinian rings. Nilpotent elements of a ring R. Nil and nilpotent ideals. Hilbert Basis Theorem. Structure theorem for finite Boolean rings. Wedeerburn-Artin theorem and its consequences. Uniform modules. Primary modules. Nother-laskar Theorem.
(Scope of the course as given in the book at Sr. No. 2).

Recommended Books:

1. I.S. Luthar and I.B.S. Passi :Algebra Vol. 1 Groups (Narosa publication House)
2. P.B. Bhattacharya S.R. Jain and S.R. Nagpal: Basic Abstract Algebra

Reference Books:

1. I.D. Macdonald	:	Theory of Groups
2. Vivek Sahai and Vikas Bist	:	Algebra (Narosa publication House)
3. Surjit Singh and Quazi Zameeruddin	:	Modern Algebra (Vikas Publishing House 1990)
4.W.R. Scott	:	Group Theory

MSM-102: COMPLEX ANALYSIS

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**

Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

Section-I (Four Questions)

Analytic functions, Harmonic functions,Uniquely Determined Analytic Functions, Reflection principle.

Elementary Functions: Exponential Functions, Logarithmic Functions, Trigonometric Functions, Hyperbolic Functions, Inverse Trigonometric Functions, Inverse Hyperbolic Functions, Complex exponents.

Complex Integration: Definite integral; Contours; Branch cuts; Cauchy-Goursat theorem. Simply connected domains, Multiply connected domains, Cauchy integral formula.

Morera's theorem; Liouville's theorem; Fundamental theorem of algebra; Maximum modulus principle;

Power series:Uniform and absolute convergence, differentiation and integration of power series, multiplication and division of power series; Taylor series; Laurentseries;

Section-II (Four Questions)

Singularities; Poles; Residues.Cauchy's Residue Theorem; Zeros of an analytic function.

Evaluation of improper integrals; Jordan's lemma; Indentation; Integration along a branch cut; Definite integrals involving sines and cosines; winding number of closed curve; Open mapping theorem; Argument principle; Rouche's theorem; Schwarz Lemma

Transformations: linear, bilinear (Mobius), sine, z^2, $z^{1/2}$; Riemann surfaces;

Mapping: Isogonal; Conformal; Scale factors; Local inverses; Harmonic conjugates; Transformations of harmonic functions, Transformations of Boundary conditions;

Recommended Text Book:

1. Churchill, R.V. and Brown, J.W., Complex Variables and Applications, Eighth edition; McGraw Hill International Edition ,2009.

Reference Books :

1. Ahlfors, L.V., Complex Analysis. McGraw-Hill Book Company, 1979.
2. Conway, J.B., Functions of One complex variables Narosa Publishing, 2000.
3. Priestly, H.A., Introduction to Complex Analysis Claredon Press, Orford, 1990.
4. D.Sarason, Complex Function Theory, Hindustan Book Agency, Delhi, 1994.
5. Mark J.Ablewitz and A.S.Fokas, Complex Variables : Introduction & Applications, Cambridge University Press, South Asian Edition, 1998.
6. E.C.Titchmarsn, The Theory of Functions, Oxford University Press, London.
7. S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.

MSM-103: ORDINARY DIFFERENTIAL EQUATIONS

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**

Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

<u>Section –I (Four Questions)</u>

Preliminaries: Initial value problem and equivalent integral equation, ε-approximate solution, equicontinuous set of functions.Basic theorems: Ascoli- Arzela theorem, Cauchy –Peano existence theorem and its corollary. Gronwall's inequality.

Lipschitz condition.Uniqueness of solutions.Successive approximations.Picard-Lindelöf theorem.Continuation of solution, Maximal interval of existence, Extension theorem.

(Relevant portions from the book of 'Theory of Ordinary Differential Equations' by Coddington and Levinson)

Higher order equations: Linear differential equation (LDE) of order n; Linear combinations, Linear dependence and linear independence of solutions. Wronskian theory: Definition, necessary and sufficient condition for linear dependence and linear independence of solutions of homogeneous LDE. Abel's Identity, Fundamental set.More Wronskian theory.Reduction of order.

Non-homogeneous LDE.Variation of parameters.Adjoint equations, Lagrange's Identity, Green's formula.Linear equation of order n with constant coefficients.

(Relevant portions from the books of 'Theory of Ordinary Differential Equations' by Coddington and Levinson and the book 'Differential Equations' by S.L. Ross)

<u>Section-II(Four Questions)</u>

Linear second order equations: Preliminaries, self adjoint equation of second order, basic facts.Superposition Principle.Riccati's equation.Prüffer transformation.Zero of a solution.Abel's formula.Common zeros of solutions and their linear dependence.

Sturm theory: Sturm separation theorem, Sturm fundamental comparison theorem and their corollaries.

Oscillatory and non-oscillatory equations.Elementary linear oscillations.

(Relevant portions from the book 'Differential Equations' by S.L. Ross and the book 'Textbook of Ordinary Differential Equations' by Deo et al.)

Second order boundary value problems(BVP): Linear problems; periodic boundary conditions, regular linear BVP, singular linear BVP; non-linear BVP. Sturm-Liouville BVP: definitions, eigen values and eigen functions. Orthogonality of functions, orthogonality of eigen functions corresponding to distinct eigen values.

Green's function. Applications of Green's function for solving boundary value problems. Use of Implicit function theorem and Fixed point theorems for periodic solutions of linear and non-linear equations.

(Relevant portions from the book 'Textbook of Ordinary Differential Equations' by Deo et all)

Recommended books:

1. E.A. Coddington and N. Levinson, *Theory of Ordinary Differential Equations*, Tata McGraw-Hill , 2000.
2. S.L. Ross, *Differential Equations*, John Wiley & Sons,
3. S.G. Deo, V. Lakshmikantham and V. Raghavendra, *Textbook of Ordinary Differential Equations*, Tata McGraw-Hill , 2006.

Reference books:

1. P. Hartman, *Ordinary Differential Equations*, John Wiley & Sons NY, 1971.
2. G. Birkhoff and G.C. Rota, *Ordinary Differential Equations*, John Wiley & Sons, 1978.
3. G.F. Simmons, *Differential Equations*, Tata McGraw-Hill , 1993.
4. I.G. Petrovski, *Ordinary Differential Equations*, Prentice-Hall, 1966.
5. D. Somasundaram, *Ordinary Differential Equations, A first Course*, Narosa Pub., 2001.
6. Mohan C Joshi, *Ordinary Differential Equations, Modern Perspective*, Narosa Publishing House, 2006.

MSM-104: REAL ANALYSIS

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**

Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

<u>Section-I (Four Questions)</u>

Definition and existence of Riemann Stieltjes integral, properties of the integral, reduction of Riemann Stieltjes integral to ordinary Riemann integral, change of variable, integration and differentiation, the fundamental theorem of integral calculus, integration by parts, first and second mean value theorems for Riemann Stieltjes integrals, integration of vector-valued functions, rectifiable curves. (Scope as in Chapter 6 of 'Principles of Mathematical Analysis' by Walter Rudin, Third Edition).

Sequences and series of functions : Pointwise and uniform convergence of sequences of functions, Cauchy criterion for uniform convergence, Dini's theorem, uniform convergence and continuity, uniform convergence and Riemann integration, uniform convergence and differentiation, convergence and uniform convergence of series of functions, Weierstrass M-test, integration and differentiation of series of functions, existence of a continuous nowhere differentiable function, the Weierstrass approximation theorem, the Arzela theorem on equicontinuous families. (Scope as in Chapter 9 (except 9.6) & Chapter 10 (except 10.3) of 'Methods of Real Analysis' by R.R. Goldberg).

<u>Section-II (Four Questions)</u>

Functions of several variables : Linear transformations, the space of linear transformations on R^n to R^m as a metric space, open sets, continuity, derivative in an open subset of R^n, chain rule, partial derivatives, directional derivatives, continuously differentiable mappings, necessary and sufficient conditions for a mapping to be continuously differentiable, contractions, the contraction principle (fixed point theorem), the inverse function theorem, the implicit function theorem. (Scope as in relevant portions of Chapter 9 of 'Principles of Mathematical Analysis' by Walter Rudin, Third Edition)

Power Series : Uniqueness theorem for power series, Abel's and Tauber's theorem, Taylor's theorem, Exponential & Logarithmic functions, trigonometric functions, Fourier series, Gamma function (Scope as in relevant portions of Chapter 8 of 'Principles of Mathematical Analysis' by Walter Rudin, Third Edition).

Recommended Text:

'Principles of Mathematical Analysis' by Walter Rudin (3rd Edition) McGraw-Hill, 1976.
'Methods of Real Analysis' by R.R.Goldberg, Oxford and IHB Publishing Company, New Delhi, 1970

Reference Books :

1. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
2. Gabriel Klambauer, Mathematical Analysis, Marcel Dekkar, Inc. New York, 1975.
3. A.J. White, Real Analysis; an introduction. Addison-Wesley Publishing Co., Inc., 1968.
4. E. Hewitt and K. Stromberg. Real and Abstract Analysis, Berlin, Springer, 1969.
5.Serge Lang, Analysis I & II, Addison-Wesley Publishing Company Inc., 1969.
6. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi,4th Edition 2010.
7.D. Somasundaram and B. Choudhary : A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997

MSM-105: TOPOLOGY

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**
Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

<u>Section-I (Four Questions)</u>

Definition and examples of topological spaces, Neighbourhoods, Neighbourhood system of a point and its properties, Interior point and interior of a set, interior as an operator and its properties, definition of a closed set as complement of an open set, limit point (accumulation point) of a set, derived set of a set, adherent point (Closure point) of a set, closure of a set, closure as an operator and its properties, boundary of a set, Dense sets. Base for a topology and its characterization, Base for Neighbourhood system, Sub-base for a topology. Relative (induced) Topology and subspace of a topological space. Alternate methods of defining a topology using 'properties' of 'Neighbourhood system', 'Interior Operator', 'Closed sets', Kuratowski closure operator. First countable, Second countable and separable spaces, their relationships and hereditary property. About countability of a collection of disjoint open sets in a separable and a second countable space, Lindelof theorem.

Comparison of Topologies on a set, about intersection and union of topologies, the collection of all topologies on a set as a complete lattice Definition, examples and characterisations of continuous functions, composition of continuous functions, Open and closed functions, Homeomorphism, embedding. Tychonoff product topology, projection maps, their continuity and openness, Characterization of product topology as the smallest topology with projections continuous, continuity of a function from a space into a product of spaces. T_0 , T_1, T_2, Regular and T_3 Separation axioms, their characterization and basic properties i.e. hereditary and productive properties. Quotient topology w.r.t. a map, Continuity of function with domain a space having quotient topology, About Hausdorffness of quotient space

<u>SECTION-II (Four Questions)</u>

Completely regular and Tychonoff ($T_{3\,1/2}$), spaces, their hereditary and productive properties. Embedding lemma, Embedding theorem. Normal and T_4 spaces : Urysohn's Lemma, complete regularity of a regular normal space, Tietze's extension theorem (Statement only).

Definition and examples of filters on a set, Collection of all filters on a set as a p.o. set, finer filter, methods of generating filters/finer filters, Ultra filter (u.f.) and its characterizations, Ultra Filter Principle (UFP). Image of a filter under a function. Convergence of filters: Limit point (Cluster point) and limit of a filter and relationship between them, Continuity in terms of convergence of filters. Hausdorffness and filter convergence.

Compactness: Definition and examples of compact spaces, definition of a compact subset as a compact subspace, relation of open cover of a subset of a topological space in the sub-space with that in the main space, compactness in terms of finite intersection property (f.i.p.), continuity and compact sets, compactness and separation properties, closeness of continuous map from a compact space into a Hausdorff space and its consequence, Regularity and normality of a compact Hausdorff space. Compactness and filter convergence, Convergence of filters in a product space, compactness and product space. Tychonoff product theorem, Tychonoff space as a subspace of a compact Hausdorff space and its converse, compactification and Hausdorff compactification, Stone-Cech compactification, (Scope of the course is as given in chapters 1, 3, 4 & 5 of the Kelley's book given at Sr. No. 1).

Books :

1. Kelley, J.L. : General Topology.
2. Munkres, J.R. : Topology, Second Edition, Prentice Hall of India/ Pearson

MSM-106: PRACTICAL-I

External Theory Examination: 35 Marks **Internal Assessment: 15 Marks**
Time: 4 Hours

Part A : Problem Solving

In this part problem solving techniques based on papers MSM 101 to MSM 105 will be taught.

Part B : **ANSI-C codes for following mathematical problems**

1. Use of nested **if.. .else** in finding the smallest of four numbers.
2. To find if a given 4-digit year is a leap year or not.
3. To compute AM, GM and HM of three given real values.
4. To invert the order of digits in a given positive integral value.
5. Use series sum to compute **sin(x)** and **cos(x)** for given angle **x** in degrees. Then, check error in verifying $\mathbf{sin^2x+cos^2(x)=1}$.
6. Verify $\sum n^3 = \{\sum n\}^2$, (where n=1,2,..,m) & check that prefix and postfix increment operator gives the same result.
7. Compute simple interest and compound interest for a given amount, time period, rate of interest and period of compounding.
8. Program to multiply two given matrices in a user defined function.
9. Calculate standard deviation for a set of values {x(j) , j=1,2,...,n} having the corresponding frequencies {f(j) , j=1,2,...,n}.
10. Write the user-defined function to compute GCD of two given values and use it to compute the LCM of three given integer values.
11. Compute GCD of 2 positive integer values using recursion / pointer to pointer.
12. Check a given square matrix for its positive definite form.
13. To find the inverse of a given non-singular square matrix.
14. To convert a decimal number to its binary representation.
15. Use array of pointers for alphabetic sorting of given list of English words.

Note :

Every student will have to prepare a file to maintain practical record of the problems solved and the computer programs done during practical class-work. Examination will be conducted through a question paper set jointly by the external and internal examiners. An examinee will be asked to write the solutions in the answer book. An examinee will be asked to run (execute) two or more computer programs on a computer. Evaluation will be made on the basis of the examinee’s performance in written solutions/programs, execution of computer programs and viva-voce examination.

SYLLABUS FOR M.SC MATHEMATICS SEMESTER – II

MSM-201: ADVANCED ABSTRACT ALGEBRA

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**
Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

Section-I (Four Questions)

Characteristic of a ring with unity. Prime fields Z/pZ and Q. Characterization of prime fields. Field extensions. Degree of an extension. Algebraic and transcendental elements. Simple field extensions. Minimal polynomial of an algebraic element. Conjugate elements. Algebraic extensions. Finitely generated algebraic extensions. Algebraic closure and algebraically closed fields. Splitting fields.

Finite fields. Flobineous automorphism of a finite field. Roots of unity, Cyclotomic polynomials and their irreducibility over Q. Normal extensions. Finite normal extensions as Splitting fields. Separable elements, separable polynomials and separable extensions. Theorem of primitive element. Perfect fields.
(Scope of the course as given in the book at Sr. No. 2).

Section – II (Four Questions)

Galois extensions. Galois group of an extension. Dedekind lemma Fundamental theorem of Galois theory. Frobenius automorphism of a finite field. Klein's 4-group and Diheadral group. Galois groups of polynomials. Fundamental theorem of Algebra. Radicals extensions. Galois radical extensions. Cyclic extensions. Solvability of polynomials by radicals over Q. Symmetric functions and elementary symmetric functions. Construction with ruler and compass only.
(Scope of the course as given in the book at Sr. No. 2).

Similar linear transformations. Invariant subspaces of vector spaces. Reduction of a linear transformation to triangular form. Nilpotent transformations. Index of nilpotency of a nilpotent transformation. Cyclic subspace with respect to a nilpotent transformation. Uniqueness of the invariants of a nilpotent transformation. Primary decomposition theorem. Jordan blocks and Jordan canonical forms. Cyclic module relative to a linear transformation. Rational Canonicals form of a linear transformation and its elementary divisior. Uniqueness of the elementary divisior.
(Sections 6.4 to 6.7 of the book. Topics in Algebra by I.N. Herstein).

Recommended Books:

1. I.N. Herstein :Topics in Algebra (Wiley Eastern Ltd.)
2. P.B. Bhattacharya S.K. Jain & S.R. Nagpal : Basic Abstract Algebra (Cambridge University Press 1995)

Reference Books:

1. Vivek Sahai and Vikas Bist : Algebra (Narosa publication House)
2. Surjit Singh and Quazi Zameeruddin : Modern Algebra (Vikas Publishing House 1990)
3. Patrick Morandi : Field and Galois Theory (Springer 1996)

MSM-202: COMPUTER PROGRAMMING (THEORY)

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**

Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

Section-I

Numerical constants and variables; arithmatic expressions; input/output statements; conditional flow; looping; logical expressions and control flow; functions; subroutines; arrays.

(Relevant portions of chapters 1 to 10 of the recommended text book)

Section-II

Format specifications; strings; array arguments; derived data types; processing files; pointers; FORTRAN 90 features; FORTRAN 95 features.

(Relevant portions of chapters 11-12, 14-15, 17-18 and 20-21 of the recommended text book)

Recommended Text

V. Rajaraman : Computer Programming in FORTRAN 90 and 95; Printice-Hall of India Pvt. Ltd., New Delhi, 1997.

References

1. V. Rajaraman : Computer Programming in FORTRAN 77, Printice-Hall of India Pvt. Ltd., New Delhi, 1984.
2. J. F. Kerrigan : Migrating to FORTRAN 90, Orielly Associates, CA, USA, 1993.
3. M. Metcalf and J. Reid : FORTRAN 90/95 Explained, OUP, Oxford, UK, 1996.

MSM-203: MEASURE AND INTEGRATION

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**

Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

Section-I (Four Questions)

Lebesgue outer measure, elementary properties of outer measure, Measurable sets and their properties, Lebesgue measure of sets of real numbers, algebra of measurable sets, Borel sets and their measurability, characterization of measurable sets in terms of open, closed, $F\sigma$ and G_δ sets, existence of a non-measurable set.

Lebesgue measurable functions and their properties, the almost everywhere concept , characteristic functions, simple functions, approximation of measurable functions by sequences of simple functions, Borel measurability of a function.

Littlewood's three principles, measurable functions as nearly continuous functions. Lusin's theorem, almost uniform convergence, Egoroff's theorem, convergence in measure, F.Riesz theorem that every sequence which is convergent in measure has an almost everywhere convergent subsequence.

The Lebesgue Integral : Shortcomings of Riemann integral, Lebesgue integral of a bounded function over a set of finite measure and its properties, Lebsegue integral as a generalization of the Riemann integral, Bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions.

Section-II (Four Questions)

Integral of a non negative function, Fatou's lemma, Monotone convergence theorem, integration of series, the general Lebesgue integral, Lebesgue convergence theorem.

Differentiation and Integration : Differentiation of monotone functions, Vitali's covering lemma, the four Dini derivatives, Lebesgue differentiation theorem, functions of bounded variation and their representation as difference of monotone functions.

Differentiation of an integral, absolutely continuous functions, convex functions, Jensen's inequality.

The L^p spaces, Minkowski and Holder inequalities, completeness of L^p spaces, Bounded linear functionals on the L^p spaces, Riesz representation theorem.

Recommended Text :

'Real Analysis' by H.L.Royden (3rd Edition) Prentice Hall of India, 1999.

Reference Books :

1. G.de Barra, Measure theory and integration, Willey Eastern Ltd.,1981.
2. P.R.Halmos, Measure Theory, Van Nostrans, Princeton, 1950.

3. I.P.Natanson, Theory of functions of a real variable, Vol. I, Frederick Ungar Publishing Co., 1961.
4. R.G.Bartle, The elements of integration, John Wiley & Sons, Inc.New York, 1966.
5. K.R.Parthsarthy, Introduction to Probability and measure, Macmillan Company of India Ltd.,Delhi, 1977.
6. P.K.Jain and V.P.Gupta, Lebesgue measure and integration, New age International (P) Ltd., Publishers, New Delhi, 1986.

MSM-204: MECHANICS OF SOLIDS

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**

Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

SECTION-I (Four Questions)

Tensor Algebra: Coordinate-transformation, Cartesian Tensor of different order.
Properties of tensors.Isotropic tensors of different orders and relation between them.Symmetric and skew symmetric tensors.Tensor invariants.Deviatoric tensors.Eigen-values and eigen-vectors of a tensor.
Tensor Analysis: Scalar, vector, tensor functions, Comma notation, Gradient, divergence and curl of a vector / tensor field. (Relevant portions of Chapters 2 and 3 of book by D.S. Chandrasekharaiah and L.Debnath)

Analysis of Strain : Affine transformation, Infinitesimal affine deformation, Geometrical Interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariance, General infinitesimal deformation. Saint-Venant's equations of compatibility.

Analysis of Stress : Stress Vector, Stress tensor, Equations of equilibrium, Transformation of coordinates.Stress quadric of Cauchy, Principal stress and invariants.Maximum normal and shear stresses.Mohr’s circles.Examples of stress.
(Relevant portions of Chapter 1 & 2 of the book by I.S. Sokolnikoff).

SECTION-II (Four Questions)

Equations of Elasticity :Generalised Hooks Law, Anisotropic symmetries, Homogeneous isotropic medium.Elasticity moduli for Isotropic media.Equilibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its connection with Hooke’s Law.
Beltrami-Michell compatibility equations.Uniqueness of solution.Clapeyron’s theorem.Saint-Venant's principle.
(Relevant portions of Chapter 3 of book by I.S. Sokolnikoff).

Variational Methods: Theorem of minimum potential energy. Theorem of minimum complementary energy.Reciprocal theorem of Betti and Rayleigh.Ritz, Galerkin and Kantorovich methods.
(Relevant portions of Chapter 7 of the book by I.S. Sokolnikoff).

Recommended Books:

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata-McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. D.S. Chandrasekharaiah and L. Debnath, Continuum Mechanics, Academic Press, 1994.

Reference Books:

1. A.E.H. Love, A Treatise on the Mathematical Theory of Elasticity Dover Publications, New York.
2. Y.C. Fung. Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
3. Shanti Narayan, Text Book of Cartesian Tensor, S. Chand & Co., 1950.
4. S. Timeshenko and N. Goodier. Theory of Elasticity, McGraw Hill, New York, 1970.
5. I.H. Shames, Introduction to Solid Mechanics, Prentice Hall, New Delhi, 1975.

MSM-205: SYSTEM OF DIFFERENTIAL EQUATIONS

External Theory Examination: 70 Marks **Internal Assessment: 30 Marks**

Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

Section –I (Four Questions)

Linear differential systems: Definitions and notations. Linear homogeneous systems; Existence and uniqueness theorem, Fundamental matrix,Adjoint systems, reduction to smaller homogeneous systems.

Non-homogeneous linear systems; variation of constants.Linear systems with constant coefficients.Linear systems with periodic coefficients; Floquet theory.
(Relevant portions from the book of 'Theory of Ordinary Differential Equations' by Coddington and Levinson)

System of differential equations.Differential equation of order n and its equivalent system of differential equations.Existence theorem for solution of system of differential equations. Dependence of solutions on initial conditions and parameters: Preliminaries, continuity and differentiability.
(Relevant portions from the book of 'Theory of Ordinary Differential Equations' by Coddington and Levinson)

Maximal and Minimal solutions.Upper and Lower solutions.Differential inequalities.
(Relevant portions from the book 'Textbook of Ordinary Differential Equations' by Deo et al.)

Section –II (Four Questions)

Autonomous systems: the phase plane, paths and critical points, types of critical points; Node, Center, Saddle point, Spiral point. Stability of critical points. Critical points and paths of linear systems: basic theorems and their applications.Critical points and paths of quasilinear systems.
(Relevant portions from the book 'Differential Equations' by S.L. Ross)

Stability Analysis : Asymptotic behaviour of linear system, generalized Gronwall's inequality. Formal approach of stability analysis. Phase portrait analysis.
(Relevant portions from the book of 'Ordinary Differential Equations' by Mohan C Joshi)

Stability of solution of system of equations with constant coefficients, linear equation with constant coefficients.Liapunov stability. Stability of quasi linear systems.
(Relevant portions from the book 'Textbook of Ordinary Differential Equations' by Deo et al.)

Limit cycles and periodic solutions: limit cycle, existence and non-existence of limit cycles, Benedixson's non-existence theorem. Half-path or Semiorbit, Limit set, Poincare-Benedixson theorem.
(Relevant portions from the book 'Differential Equations' by S.L. Ross and the book 'Theory of Ordinary Differential Equations' by Coddington and Levinson)

Recommended books:

1. E.A. Coddington and N. Levinson, *Theory of Ordinary Differential Equations*, Tata McGraw-Hill , 2000.
2. S.L. Ross, *Differential Equations*, John Wiley & Sons,
3. S.G. Deo, V. Lakshmikantham and V. Raghavendra, *Textbook of Ordinary Differential Equations*, Tata McGraw-Hill , 2006.

4. Mohan C Joshi, *Ordinary Differential Equations, Modern Perspective*, Narosa Publishing House, 2006.

Reference books:

1. P. Hartman, *Ordinary Differential Equations*, John Wiley & Sons NY, 1971.
2. G. Birkhoff and G.C. Rota, *Ordinary Differential Equations*, John Wiley & Sons, 1978.
3. G.F. Simmons, *Differential Equations*, Tata McGraw-Hill , 1993.
4. I.G. Petrovski, *Ordinary Differential Equations*, Prentice-Hall, 1966.
5. D. Somasundaram, *Ordinary Differential Equations, A first Course*, Narosa Pub., 2001.

MSM-206: PRACTICAL-II

External Theory Examination: 35 Marks **Internal Assessment: 15 Marks**

Time: 4 Hours

Part A: Problem Solving

In this part problem solving techniques based on papers MSM 201 to MSM 205 will be taught.

Part B: **FORTRAN-90 codes for Mathematical problems**

1. Given the centre and a point on the boundary of a circle, find its perimeter and area.
2. Calculate the area of a regular polygon for its given perimeter.
3. To check an equation $ax^2+ by^2+2cx+2dy+e=0$ in (x, y) plane with given coefficients for representing parabola/ hyperbola/ ellipse/ circle or else.
4. To solve a quadratic equation with given coefficients, without using COMPLEX data type.
5. To find the location of a given point (x,y) i) at origin, ii) on x-axis or y-axis iii) in quadrant I, II, III or IV.
6. Use a function program for simple interest to display year-wise compound interest and amount, for given deposit, rate, time and compounding period.
7. To find the number of days in a given month of any given 4-digit year.
8. Use procedure for the greatest common divisor (gcd) of two given positive integers to compute the least common multiple (lcm) of three given positive integer values.
9. Find error in verifying sin(x+y)= sin(x) cos(y)+cos(x)sin(y), by approximating the sin(x) and cos(x) functions from the finite number of terms in their series expansions.
10. Use SELECT…CASE to calculate the income tax on a given income at the existing rates.
11. Use string operations to find if a given string is a palindrome or not.
12. To compute the arithmetic mean, geometric mean and harmonic mean for the values $\{x(j), j=1,2,\ldots,n\}$ having the corresponding frequencies $\{f(j), j=1,2,\ldots,n\}$.
13. Product of two given matrices.
14. Least square fitting of a straight line to given set of points on a plane.
15. To solve a quadratic equation with given (complex-valued) coefficients, using COMPLEX data type.

Note :

Every student will have to prepare a file to maintain practical record of the problems solved and the computer programs done during practical class-work. Examination will be conducted through a question paper set jointly by the external and internal examiners. An examinee will be asked to write the solutions in the answer book. An examinee will be asked to run (execute) two or more computer programs on a computer. Evaluation will be made on the basis of the examinee’s performance in written solutions/programs, execution of computer programs and viva-voce examination.

OPEN ELECTIVE PAPER OE-207: APPLIED ALGEBRA AND ANALYSIS

External Theory Examination: 35 Marks **Internal Assessment: 15 Marks**
Time: 3 Hours

NOTE: The examiner is requested to set eight questions in all by taking four questions from each section. The examinee will be required to attempt five questions by selecting at least two questions from each section.

Section I

Direct sum and Direct product (Kronecker product) of matrices and their properties, Gram matrices, Rank of a Gram matrix, Quadratic forms associated with a Gram matrix.

Lattices and their examples, distributive and complemented lattices, Boolean algebras, Boolean polynomials, Boolean functions, applications to switching circuit theory.

Lie algebras, examples of Lie algebras, subalgebras and ideals of Lie algebras, homorphisms of Lie algebras, derivation on Lie algebras, structure constants, quotient algebras, Lie algebras of dimensions 1 and 2, Heisenberg algebra.

(Scope of this section is as in relevant portions of the books mentioned at serial number 1, 2 and 3)

Section II

Metric spaces and normed linear spaces: Definitions and examples, metrics generated by a norm, Cauchy-Schwarz inequality, Holder inequality, Minkowski equality; co-ordinate spaces (Euclidean n-space, Unitary n-space), sequence spaces (Hilbert sequence space l_2) and function spaces (C[a,b]).

Balls and boundedness: Balls and spheres in metric and normed linear spaces, relating norms and balls, symmetry and convexity of the unit sphere and unit balls, boundedness, diameter of a set, distance between sets.

Limit processes: Convergence of sequences, equivalence of convergence and co-ordinatewise convergence in Euclidean space, equivalent metrics and norms, Cauchy sequences, completeness, Banach spaces, completeness of discrete metric space, Euclidean n-spaces, Unitary n-spaces and B(X).

Application: Fixed points, fixed points of translation mapping, rotation mapping, reflection mapping ; Contraction mapping, Banach's fixed point theorem, Applications of Banach's fixed point theorem in numerical analysis.

(Scope of this section is as in relevant portions of the book 'Introduction to the Analysis of Metric Spaces' by J. R. Giles)

Recommended texts:

1. C. L. Liu: Elements of Discrete Mathematics (2nd Edition), Tata-McGraw-Hill Publishing Company Ltd., 2000.
2. Karin Erdmann and Mark J. Wildon: Introduction to Lie Algebras, Springer, 2006.
3. Shanti Narayan: A text book of matrices, S. Chand & Company (Pvt) Ltd., 1988.
4. J. R. Giles: Introduction to the Analysis of Metric Spaces, Cambridge University Press, 1987.