திருவள்ளுவர் பல்கலைக்கழகம்

THIRUVALLUVAR UNIVERSITY

MASTER OF SCIENCE DEGREE COURSE

M.Sc. MATHEMATICS under CBCS

REGULATIONS

CBCS PATTERN

with effect from 2018 – 2019

Definitions:

Programme **:** "Programme" means a course of study leading to the award of a degree in a discipline.

Course **:** "Course" refers to a paper / practical / subject offered under the degree programme.
Each Course is to be designed variously under lectures / tutorials / laboratory or field work / seminar / practical training / Assignments / Term paper or Report writing etc., to meet effective teaching and learning needs.

i) Core Courses:
"The Core Courses" related to the programme concerned including practicals offered in the programme".

ii) Elective Courses:
"Elective courses" related to the core courses of the programme concerned, offered in the programme".

A detailed explanation of the above with relevant credits are given under **"Scheme of Examination along with Distribution of Marks and Credits"**

Duration **:** This means the stipulated years of study to complete a programme as prescribed by the University from time to time. Currently for the postgraduate programme the duration of study is TWO years. These regulations shall apply to the regular course of study in approved institutions of the University.

Credits **:** The weightage given to each course of study (subject) by the experts of the Board of Studies concerned.

The term 'Credit' refers to the weightage given to a course, usually in relation to the instructional hours assigned to it. For instance, a six hour course per week is assigned 6/5/4 credits, a five hour course per week is assigned 5/4/3 credits and a four hour course per week is given 4/3/2 credits. However, in no instance the credits of a course can be greater than the hours allotted to it.

The total minimum credits, required for completing a PG program is 90.

Credit System **:** The course of study under this regulation, where weightage of credits are spread over to different semesters during the period of study and the Cumulative Grade Point Average shall be awarded based on the credits earned by the students. A total of 90 credits are prescribed for the Postgraduate Programme offered in two years.

Choice Based **:** All Postgraduate Programmes offered by the University shall be under Choice Based Credit System.

Choice Based Credit System (CBCS): This is to enhance the quality and mobility of the students within and between the Universities in the country and abroad.

1. Eligibility for Admission to the Course:

A candidate who have passed the B.Sc. Degree Examination in Mathematics of this University or an Examination of any other University with more than one major with Mathematics accepted by the Syndicate as equivalent thereto shall be permitted to appear and qualify for the Master of Science (M.Sc.) Degree Examination of this University after a Course of two academic years in the University Department / Colleges affiliated to this University.

No student shall be eligible for admission to a Master's degree programme in any of the faculties unless he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits for an undergraduate degree through the examinations conducted by a University / autonomous institution or possesses such qualifications recognized by the Thiruvalluvar University as equivalent to an undergraduate degree. Provided that candidates for admission into the specific main subject of study shall also possess **such other qualifying conditions as may be prescribed by the University in the Regulations** governing respective courses of study.

2. Duration of the Course:

The course shall extend over a period of **two years comprising** of four semesters with two semesters in one academic year. There shall not be less than 90 working days for each semester. Examination shall be conducted at the end of every semester for the respective subjects.

Each semester have 90 working days consists of 5 teaching hours per working day. Thus, each semester has 450 teaching hours and the whole programme has 1800 teaching hours. The odd semesters shall consist of the period from July to November and the even semesters from December to April.

3. Course of Study:

The course of study for Masters Degree Course in Mathematics shall consist of Core, Elective subjects and a Compulsory subject (Human Rights) and a Project in the fourth semester.

4. Distribution of Credit Points and Marks:

The Minimum Credit Requirement for a two year Master's programme shall be 90 (ninety) Credits. The break-up of credits for the programme is as follows:

(a). Core Courses : 71 credits

(b). Elective Courses : 17 credits

(c). Compulsory course : 2 credits

5. Continuous Internal Assessment Test:

The following assessment procedure will be followed for awarding the internal marks in the evaluation of the student's performances. The best 2 CIA test marks out of 3 CIA tests marks, will be taken for awarding the internal marks.

(a). CIA Test Marks : 15 marks.

(b). Seminar : 5 marks.

(c). Assignment : 5 marks

Total : 25 marks

6. Requirement to appear for the examinations

a) A candidate shall be permitted to appear for the university examinations for any semester (theory as well as practical) if

i. He/she secures **not less than 75%** of attendance in theory as well as in practicals (separate attendance registers shall be maintained for theory and practical) in the number of working days during the semester.

ii. In the case of married woman candidates the minimum attendance requirement shall be not less than 55% of the total instructional days in theory as well as in practical.

iii. His/her conduct shall be satisfactory. Provided that it shall be open to the Syndicate, or any authority delegated with such powers by the Syndicate, to grant exemption to a candidate who has failed to earn 75% of the attendance in theory as well as in practical, prescribed, for valid reasons, subject to usual conditions.

b) A candidate who has secured **less than 75% but 65%** and above attendance in any semester separately for theory and practical, shall be permitted to take the examination on the recommendations of the Head of the Department to condone the lack of attendance on the payment of prescribed fees to the University, separately for theory and practical.

c) A candidate who has secured **less than 65% but 55%** and above attendance in any semester in theory as well as in practical, has to compensate the shortage in attendance in the subsequent semester (in the next year) besides earning the required percentage of attendance in that semester and appear for both semester papers together at the end of the later semester, on the payment of prescribed fees to the University, separately for theory and practical. However, shortage of attendance in I-semester shall be compensated while studying in III semester, shortage of attendance in II-semester shall be compensated while studying in IV semester, shortage of attendance in III&IV-semesters shall be compensated after rejoining the course in the 3rd year. Also, separate attendance registers shall be maintained in theory as well as practical, for compensating the shortage of attendance. During the hours of compensation of attendance, the candidate shall not be given attendance for the regular semester classes.

d) A candidate who has secured **less than 55%** of attendance in any semester separately for theory and practical shall not be permitted to appear for the regular examinations in that particular semester or in subsequent semesters. He/she has to rejoin/ re-do the semester in which the attendance is less than 55%, on the payment of prescribed fees to the University, separately for theory and practical, after getting prior approval of the University.

e) A candidate who has secured **less than 65%** of attendance in the final semester separately for theory and practical, has to compensate his/her attendance shortage in a manner as decided by the concerned Head of the department, after getting prior approval of the University. The candidate shall be permitted to rejoin in the 4th semester, after completing his/her regular 2 year course.

7. Scheme of Examination:

a. Any theory examination is conducted only for 3 hours irrespective of total marks allotted for the examinations.

b. There shall be theory examinations at the end of each semester, for odd semesters in the month of October / November; for even semesters in April / May. However, there shall be practical examinations at the end of even semesters in general, with exceptions in a few courses as prescribed by the Boards of studies, concerned. A candidate who does not pass the examination in any course(s) shall be permitted to appear in such failed course(s) in the subsequent examinations to be held in October / November or April / May.

c. All candidates admitted in first year, should get registered for the first semester examination, compulsorily. If registration is not possible owing to any reason including shortage of attendance beyond condonation limit, belated joining or on medical grounds, the candidates are permitted to rejoin the course in the next year.

8. Restrictions to appear for the examinations:

Any candidate having arrear paper(s) shall have the option to appear in any arrear paper along with the regular semester papers, in theory as well as in practical, as long as the transitory provision is applicable.

9. Medium of Instruction and Examinations:

The medium of instruction for the courses is English only.

10. Question Paper Pattern

The Question Paper Pattern for the University theory examinations is as follows:

Time: 3 Hours Maximum Marks: 75

Part – A (10 × 2 = 20 marks)
Answer ALL Questions

(Two Questions from each unit)

Part – B (5 × 5 = 25 marks)
Answer ALL Questions

(Two Questions from each unit with internal Choice [either or type])

Part – C (3 × 10 = 30 marks)
Answer any Three Questions out of Five Questions

(One Question from each unit)

11. Passing Minimum

a). A candidate shall be declared to have passed the whole examination, if the candidate passes in all the theory papers and practical wherever prescribed as per the scheme of examinations by earning 90 credits in Core and Elective courses, including practical.

b). A candidate should get **not less than 50% in the University (external)** Examination, compulsorily, in all papers, including practical. Also the candidate who secures **not less than 5**0% marks in the external as well as internal (CIA) examinations put together in any paper / practical shall be declared to have successfully passed the examination in the subject in theory as well as practical. There shall be no passing minimum for the CIA. The candidate who absents himself for CIA programmes, even after a repeated chance, will be awarded zero mark in the concerned subject (zero to 25 for theory and zero to 40 for practical).

12. Distribution of Marks:

The following are the distribution of marks for external and internal for University (external) examination and continuous internal assessment and passing minimum marks for **theory papers of PG programmes**.

Table – 1(A)

Uni.Exam Total(ESE)	Passing Minimum For Uni.Exam	CIA Total	Passing Minimum For CIA	Total Marks Allotted	Passing Minimum (Uni.Exam+CIA)
75	**38**	**25**	**0**	**100**	**50**

The following are the Distribution of marks for the Continuous Internal Assessment in the theory papers of PG Programmes.

Table – 1(B):

S. No.	Theory	Distribution of Marks	
		Assignments	**Tests**
1.	Assignment - 1 (First 2 Units of the Syllabus)	10	---
2.	Test – 1 (First 2 Units of the Syllabus for 1 hour duration)	---	50
3.	Assignment - 2 (3^{rd} & 4^{th} Units of the Syllabus)	10	---
4.	Test – 2 (First 4 Units of the Syllabus for 2 hours duration)	---	50
5.	Seminar (Entire Syllabus)	10	---
6.	Test – 3 (Entire Syllabus for 3 hours duration)	---	100
Total Marks		**30**	**200**
Marks to be converted to		**5**	**20**
Total Maximum Marks for CIA		**25**	

13. Grading:

Once the marks of the CIA and end-semester examinations for each of the course are available, they shall be added. The mark thus obtained shall then be converted to the relevant letter grade, grade point as per the details given below:

Conversion of Marks to Grade Points and Letter Grade (Performance in a Course/Paper)

RANGE OF MARKS	GRADE POINTS	LETTER GRADE	DESCRIPTION
90-100	**9.0-10.0**	**O**	Outstanding
80-89	**8.0-8.9**	**D+**	Distinction
75-79	**7.5-7.9**	**D**	
70-74	**7.0-7.4**	**A+**	First Class
60-69	**6.0-6.9**	**A**	
50-59	**5.0-5.9**	**B**	Second Class
00-49	**0.0**	**U**	Re-appear
Absent	**0.0**	**AAA**	ABSENT

Ci= Credits earned for course i in any semester
Gi = Grade Point obtained for course i in any semester
n = refers to the semester in which such course were credited

Grade point average (for a Semester):

Calculation of grade point average semester-wise and part-wise is as follows:

- **GRADE POINT AVERAGE [GPA] = ΣiCiGi / ΣiCi**

$$GPA = \frac{\text{Sum of the multiplication of grade points by the credits of the courses offered under each part}}{\text{Sum of the credits of the courses under each part in a semester}}$$

Calculation of Grade Point Average (CGPA) (for the entire programme):

A candidate who has passed all the examinations prescribed is eligible for the following partwise computed final grades based on the range of CGPA.

CUMULATIVE GRADE POINT AVERAGE [CGPA] = ΣnΣiCniGni / ΣnΣiCni

$$CGPA = \frac{\text{Sum of the multiplication of grade points by the credits of the entire programme under each part}}{\text{Sum of the credits of the courses of the entire programme under each part}}$$

CGPA	GRADE
9.0 and above but below 10.0	O
8.0 and above but below 9.0	D+
7.5 and above but below 8.0	D
6.5 and above but below 7.5	A+
6.0 and above but below 6.5	A
5.0 and above but below 6.0	B
0.0 and above but below 5.0	U

14. Improvement of Marks in the subjects already passed:

Candidates desirous of improving the marks awarded in a passed subject in their first attempt shall reappear once within a period of subsequent two semesters by paying the fee prescribed from time to time. The improved marks shall be considered for classification but not for ranking. When there is no improvement, there shall not be any change in the original marks already awarded. If candidate improves his marks, then his improved marks will be taken into consideration for the award of Classification only. Such improved marks will not be counted for the award of Prizes / Medals, Rank and Distinction. If the Candidate does not show improvement in the marks, his previous marks will be taken into consideration.

- ❖ No candidate will be allowed to improve marks in the Practicals, Project, Viva-voce and Field work.

15. Classification of Successful candidates:

A candidate who passes all the examinations including practicals securing following CGPA and Grades shall be declared as follows **for Part I or Part II**:

CGPA	GRADE	CLASSIFICATION OF FINAL RESULT
9.0 and above but below 10.0	O	First Class - Outstanding
8.0 and above but below 9.0	D+	First Class with Distinction
7.5 and above but below 8.0	D	
6.5 and above but below 7.5	A+	First Class
6.0 and above but below 6.5	A	
5.0 and above but below 6.0	B	Second Class

a. A candidate who has passed all the examination including practicalsin the first appearance within the prescribed duration of the PG programme and secured a CGPA of 9 to 10 and equivalent grade "O" in Core and Elective subjects shall be placed in the category of "**First Class – Outstanding**".

b. A candidate who has passed all the examination including practicalsin the first appearance within the prescribed duration of the PG programmes and secured a CGPA of 7.5 to 9 and equivalent grades "D" or "D+" in Core and Elective shall be placed in the category of "**First Class with Distinction**".

c. A candidate who has passed all the examination including practicalsof the PG programme and secured a CGPA of 6 to 7.5 and equivalent grades "A" or "A+" shall be declared to have passed that parts in "**First Class**".

d. A candidate who has passed all the examination including practicalsof the PG programmes and secured a CGPA of 5.5 to 6 and equivalent grade "B" shall be declared to have passed those parts in "**Second Class**".

16. Conferment of the Degree:

No candidate shall be eligible for conferment of the Degree unless the candidate;

i. has undergone the prescribed course of study for a period of not less than four semesters in Thiruvalluvarthe University or has been exempted from in the manner prescribed and has passed the examinations as have been prescribed therefor.
ii. has completed all the components prescribed under core and elective subjects in the CBCS pattern to earn 90 credits.

17. Ranking

- A candidate who qualifies for the PG degree course passing all the examinations in the first attempt, within the minimum period prescribed for the course of study from the date of admission to the course and secures I or II class shall be eligible for ranking. In the case of candidates who pass all the examinations prescribed for the course with a break in the first appearance due to the reasons as furnished in the Regulations 6(a) (iii) supra are eligible for classification / Distinction.

The marks obtained in improvement examinations shall not be taken into consideration for ranking.

18. Revision of Regulations and Curriculum

The above Regulation and Scheme of Examinations will be in vogue without any change for a minimum period of three years from the date of approval of the Regulations. The University may revise /amend/ change the Regulations and Scheme of Examinations, if found necessary.

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THIRUVALLUVAR UNIVERSITY

MASTER OF SCIENCE IN DEGREE COURSE

M.Sc., MATHEMATICS under CBCS

(with effect from 2018 - 2019)

The course of Study and the Scheme of Examinations:

Sl. No	Study Component	Course Title	Course Code	Ins. Hrs. / Week	Credits	Title of the Paper	Maximum Marks		
							CIA	UNI. EXAM	TOTAL
	SEMESRTER - I								
1	CORE	PAPER – 1	MDMA 11	6	5	Algebra – I	25	75	100
2	CORE	PAPER – 2	MDMA 12	6	5	Real Analysis – I	25	75	100
3	CORE	PAPER – 3	MDMA 13	6	4	Ordinary Differential Equations	25	75	100
4	CORE	PAPER – 4	MDMA 14	6	4	Mechanics	25	75	100
5	ELECTIVE	PAPER – 1	MDMA15A MDMA15B MDMA15C MDMA15D MDMA15E	6	4	Elective – I A) Tensor Analysis and Relativity theory B) Special functions C) Combinatorics D) Operation Research E) Discrete Mathematics	25	75	100
Total				**30**	**22**	**Total**	**125**	**375**	**500**
	SEMESRTER – II								
1	CORE	PAPER-5	MDMA 21	6	5	Algebra – II	25	75	100
2	CORE	PAPER-6	MDMA 22	6	4	Real Analysis – II	25	75	100
3	CORE	PAPER-7	MDMA 23	5	4	Partial Differential Equations	25	75	100
4	CORE	PAPER-8	MDMA 24	6	4	Topology	25	75	100
5	ELECTIVE	PAPER-2	MDMA 25A MDMA 25B MDMA 25C MDMA 25D	5	4	Elective – II A) Fuzzy Mathematics B) Bio - Mathematics C) Stochastic Differential equations D) Cryptography and Data Security	25	75	100
6	Compulsory Paper		MDHR 20	2	2	Human Rights	25	75	100
Total				**30**	**23**	**Total**	**150**	**450**	**600**

	SEMESTER – III								
1	CORE	PAPER-9	MDMA 31	6	5	Functional Analysis	25	75	100
2	CORE	PAPER-10	MDMA 32	6	5	Complex Analysis	25	75	100
3	CORE	PAPER-11	MDMA 33	6	5	Fluid Dynamics	25	75	100
4	CORE	PAPER-12	MDMA 34	6	4	Applied Probability and Statistics	25	75	100
5	ELECTIVE	PAPER-3	MDMA 35A MDMA 35B MDMA 35C MDMA 35D MDMA 35E	6	4	Elective – III A) Financial Mathematics B) Mathematical Modelling C) Applied Algebra D) Applied Mathematical Statistics E) Stability Theory	25	75	100
Total				**30**	**23**	**Total**	**125**	**375**	**500**
	SEMESTER – IV								
1	CORE	PAPER -13	MDMA 41	6	5	Applied Numerical Analysis	25	75	100
2	CORE	PAPER -14	MDMA 42	6	4	Calculus of Variations and Integral Equations	25	75	100
3	CORE	PAPER -15	MDMA 43	6	4	Analytic Number Theory	25	75	100
4	CORE	PAPER -16	MDMA 44	6	4	Graph Theory	25	75	100
5	ELECTIVE	PAPER - 4	MDMA 45A MDMA 45B MDMA 45C MDMA 45D	6	5	ELECTIVE – IV A) LaTeX and MATlab B) Differential Geometry C) Difference Equations D) Algebraic Graph Theory	25	75	100
Total				**30**	**22**	**Total**	**125**	**375**	**500**

List of Elective Courses

Sl.No	Title
1	Discrete Mathematics
2	Differential Geometry
3	Stability Theory
4	Stochastic Differential Equations
5	Cryptography and Data Security
6	Applied Algebra
7	Algebraic Graph Theory
8	Fuzzy Mathematics
9	Difference Equations
10	Operations Research
11	Applied Statistical Methods
12	Mathematical Modelling
13	Financial Mathematics
14	Tensor Analysis and Relativity Theory
15	Bio-mathematics
16	Special functions
17	Combinatorics
18	MatLab & LaTeX

Distribution of Core, Elective and Compulsory Subjects

Subject	Papers	Credits	Total Credits	Marks	Total Marks
Core	16	4-5	71	100	1600
Elective	4	4-5	17	100	400
Compulsory	1	2	2	100	100
Total	**21**	**-**	**90**	**-**	**2100**

SEMESTER - I
ALGEBRA – I (MDMA 11)
(CORE PAPER – 1)

Unit I: Introduction to Groups

Dihedral groups – Homomorphisms and Isomorphisms - Group actions – Subgroups - Definition and Examples – Centralizers and Normalizer, Stabilizers and Kernels - Cyclic groups and Cyclic subgroups of a group – Subgroups generated by subsets of a group.

Chapter 1: 1.2, 1.6 & 1.7 and **Chapter 2:** 2.1 - 2.4. **(18 Hours)**

Unit II: Quotient Groups and Homomorphisms

Definitions and Examples – More on cosets and Lagrange's Theorem – The isomorphism theorems - Composition series and the Holder program – Transpositions and the Alternating group.

Chapter 3: **(18 Hours)**

Unit III: Group Actions

Group actions and permutation representations – Groups acting on themselves by left multiplication - Cayley's theorem – Groups acting on themselves by conjugation – The class equation – Automorphisms – The Sylow theorems – The simplicity of A_n – Direct and semi-direct products and abelian groups - Direct Products – The fundamental theorem of finitely generated abelian groups.

Chapter 4 & Chapter 5: 5.1 - 5.2 **(18 Hours)**

Unit IV: Introduction to Rings

Basic definitions and examples – Examples - Polynomial rings - Matrix rings and group rings - Ring Homomorphisms and quotient rings – Properties of Ideals - Rings of fractions – The Chinese remainder theorem.

Chapter 7: **(18 Hours)**

Unit V: Euclidean domains, principal ideal domains and unique factorization domains

Principal ideal domains – Unique factorization domains – Polynomial rings - Definitions and basic properties – Polynomial rings over fields - Polynomial rings that are unique factorization domains – Irreducibility criteria – Polynomial ring over fields.

Chapter 8 & Chapter 9: **(18 Hours)**

Text Book:

- David S. Dummit and Richard M. Foote, Abstract Algebra (Second Edition), Wiley, 2003.

References:

1. Serge Lang, Algebra, Springer, 2002.
2. I.N. Herstein. Topics in Algebra (II Edition) Wiley Eastern Limited, New Delhi, 1975.
3. M. Artin, Algebra, Prentice Hall of India, 1991.
4. N. Jacobson, Basic Algebra, Vol. I & II, published by Hindustan Publishing Company, New Delhi, 1980.
5. W.H. Freeman, published by Hindustan Publishing Company, New Delhi, 1980.
6. I.S. Luther and I.B.S. Passi, Algebra, Vol. I - Groups (1996); Vol. II *Rings*, Narosa Publishing House , New Delhi, 1999
7. Joseph A. Gallian, Contemporary Abstract Algebra, Brooks/Cole Pub Co.,2012

REAL ANALYSIS – I (MDMA 12)
(CORE PAPER – 2**)**

Unit 1: Limits and Continuity:

Connectedness, Components of a metric space, Arc wise connectedness, Uniform continuity, Uniform continuity and compact sets, Fixed-point theorem for contractions, Discontinuities of real - valued functions, Monotonic functions.

Chapter 4: 4.16 - 4.23 **(18 Hours)**

Unit 2: Derivatives:

Introduction, Definition of derivative, Derivatives and continuity, Algebra of derivatives, The chain rule, One sided derivatives and infinite derivatives, Functions with nonzero derivative, Zero derivatives and local extrema, Rolle's theorem, The Mean Value Theorem for derivatives, Intermediate –value theorem for derivatives, Taylor's formula with remainder.

Chapter 5: 5.1 - 5.12 **(18 Hours)**

Unit 3: Functions of Bounded Variations and Rectifiable Curves:

Introduction, Properties of monotonic functions, Functions of bounded variation, Total variation, Additive property of total variation, Total variation on [a, x] as a function x, Functions of bounded variation expressed as the difference of increasing functions, Continuous functions of bounded variation.

Chapter 6: 6.1 – 6.8 **(18 Hours)**

Unit 4: Riemann – Stieltjes Integral:

Introduction, Notation, The definition of the Riemann-Stieltjes integral, Linear properties, Integration by parts, Change of variable in a Riemann-Stieltjes integral, Reduction to a Riemann integral, Step functions as integrators, Reduction of a Riemann-Stieltjes integral to a finite sum, Euler's summation formula, Monotonically increasing integrators. Upper and lower integrals, Additive and linearity properties of upper and lower integrals, Riemann's condition.

Chapter 7: 7.1 - 7.13 **(18 Hours)**

Unit 5: Riemann – Stieltjes Integral (Continuation)

Comparison theorems, Integrators of bounded variation, Sufficient conditions for existence of Riemann-Stieltjes integrals, Necessary conditions for existence of Riemann-Stieltjes integrals, Mean Value Theorem for conditions for Riemann-Stieltjes integrals, The integral as a function of the interval, Second fundamental theorem of integral calculus, Change of variable in a Riemann integral, Second Mean-Value Theorem for Riemann integrals, Riemann-Stieltjes integrals depending on a parameter, Differentiation under the integral sign, Interchanging the order of integration.

Chapter 7: 7.14 - 7.25 **(18 Hours)**

Text Book:

- Tom M. Apostal, "**Mathematical Analysis**", Addison - Wesley Publishing Company, 1974.

References:

1. Walter Rudin, "**Principles of Mathematical Analysis**", Mc Graw Hill Inc, 1964.
2. Anthony W. Knapp, "**Basic Real Analysis"**, Birkhauser, 2005.
3. Wilder, R. L., "**The Foundations of Mathematics"**, second Edition, John Wiley & Sons, New York, 1965.
4. Kenneth A. Ross, "**Elementary Analysis: Theory of Calculus"**, Second edition Springer, 2013.

ORDINARY DIFFERENTIAL EQUATIONS (MDMA 13)

(CORE PAPER – 3**)**

Unit I: Linear Differential Equations of Higher Order

Introduction - Higher Order Equations - A Modeling Problem - Linear Independence - Equations with Constant Coefficients - Equations with Variable Coefficients – Wronskian - Variation of Parameters - Some Standard Methods - Method of Laplace Transforms.

Chapter 2: 2.1 - 2.10 **(18 Hours)**

Unit II: Systems of Linear Differential Equations

Introduction - Systems of First Order Equations - Model for arms Competition between two Nations - Existence and Uniqueness Theorem - Fundamental Matrix - Non-homogeneous Linear Systems - Linear Systems with Constant Coefficients - Linear Systems with Periodic Coefficients.

Chapter 4: 4.1 - 4.8 **(18 Hours)**

Unit III: Existence and Uniqueness of Solutions

Introduction – Preliminaries - Successive Approximations - Picard's Theorem - Some Examples - Continuation and Dependence on Initial Conditions – Fixed point methods.

Chapter 5: 5.1 - 5.6 **(18 Hours)**

Unit IV: Boundary Value Problems

Introduction - Strum-Liouville Problem - Green's Function - Application of Boundary Value Problems (BVP) - Picard's Theorem.

Chapter 7: 7.1 – 7.5 **(18 Hours)**

Unit V: Stability of Linear and Nonlinear Systems

Introduction - Elementary Critical Points - System of Equations with Constant Coefficients - Linear Equation with Constant Coefficients - Lyapunov Stability.

Chapter 9: 9.1 - 9.5 **(18 Hours)**

Text Book:

- S.G. Deo, V. Lakshmikantham and V. Raghavendra, "Ordinary Differential Equations", Second Edition, Tata Mc Graw-Hill publishing company Ltd, New Delhi, 2004.

References :

1. Earl. A. Coddington, "An Introduction to Ordinary Differential Equations", Prentice Hall of India, New Delhi.
2. G.F. Simmons, S.G. Krantz, "Differential Equations: Theory, Technique and Practice" Tata Mc - Graw Hill Book Company, New Delhi, India, 2007.

MECHANICS (MDMA 14)
(CORE PAPER – 4**)**

Unit - I: Introductory Concepts

The Mechanical system - Generalized coordinates - Holonomic and non- holonomic systems - constraints – Virtual work – D' Alembert's principle – Energy and Momentum.

Chapter 1: 1.1 – 1.5 **(18 Hours)**

Unit - II: Lagrange's Equations

Derivation of Lagrange's equations – Examples – integrals of motion - cyclic or ignorable coordinates.

Chapter 2: 2.1 – 2.3 **(18 Hours)**

Unit - III: Hamilton's Equations

Hamilton's principle - Hamilton's equations - other variational principle - Principle of Least action.

Chapter 4: 4.1 – 4.3 **(18 Hours)**

Unit - IV: Hamilton – Jacobi Theory

Hamilton principle function - Hamilton–Jacobi equation - Separability.

Chapter 5: 5.1 – 5.3 **(18 Hours)**

Unit - V: Canonical Transformation

Differential forms and generating functions – Special Transformations – Lagrange and Poisson brackets.

Chapter 6: 6.1 – 6.3 **(18 Hours)**

Text Book:

- D. Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985.

References:

1. H. Goldstein, Classical Mechanics (Second Edition), Narosa Publishing House, India, New Delhi.
2. N.C.Rane and P.S.C. Joag, Classical Mechanics, McGraw Hill, 1991.
3. J.L. Synge and B.A. Griffth, Principles of Mechanics (3rd Edition), McGraw Hill Book Co. New York, 1970.

ELECTIVE - I

A. TENSOR ANALYSIS AND RELATIVITY THEORY (MDMA 15A)

Unit I: Tensor Algebra

Systems of different orders – Summation convention – Kronecker symbols – Transformation of coordinates in S_n. Invariants – Covariant and Contravariant vectors – Tensors of second order – Mixed tensors – Zero tensors – Tensor field – Algebra of tensors – Equality of tensors – Symmetric and Skew -Symmetric tensors – Outer multiplication, Contraction and Inner multiplication – Quotient Law of tensors – Reciprocal tensor of tensor – Relative tensor – Cross product of vectors.

Chapter 1: 1.1 – 1.3, 1.7 & 1.8 and **Chapter 2 :** 2.1 – 2.9 of U.C. De, Absos Ali Shaikh & Joydeep Sengupta, Tensor Calculus, Narosa Publishing House, New Delhi, 2004. **(18 Hours)**

Unit II: Tensor Calculus

Riemannian space – Christoffel symbols and their properties.

Chapter 3: 3.1 – 3.2 of U.C. De, Absos Ali Shaikh & Joydeep Sengupta, Tensor Calculus, Narosa Publishing House, New Delhi, 2004. **(18 Hours)**

Unit III: Tensor Calculus (Contd …)

Covariant differentiation of tensors – Riemann-Christoffel curvature tensor – Intrinsic differentiation.

Chapter 3: 3.3 – 3.5 of U.C. De, Absos Ali Shaikh & Joydeep Sengupta, Tensor Calculus, Narosa Publishing House, New Delhi, 2004. **(18 Hours)**

Unit IV: Special Theory of Relativity

Galilean transformation – Maxwell's equations – The Ether theory – The principle of Relativity.

Relativistic Kinematics: Laurent's transformation equations – Events and simultaneity – Example – Einstein train – Time dilation – Longitudinal contraction – Invariant interval – Proper time and proper distance – World line – Example – Twin paradox – Addition of velocities – Relativistic Doppler effect.

Chapter 7: 7.1 – 7.2 of D. Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985. **(18 Hours)**

Unit V: Relativistic Dynamics

Momentum – Energy – Momentum-Energy four vector – Force – Conservation of energy – Mass and energy – Example – Inelastic collision – Principle of equivalence – Lagrangian and Hamiltonian formulations.

Accelerated Systems: Rocket with constant acceleration – Example – Rocket with constant thrust.

Chapter 7: 7.3 – 7.4 of D. Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985. **(18 Hours)**

References:

1. J.L.Synge & A.Schild, Tensor Calculus, Toronto, 1949.
2. A.S.Eddington, The Mathematical Theory of Relativity, Cambridge University Press, 1930.
3. P.G.Bergman, An Introduction to Theory of Relativity, New York, 1942.
4. C.E.Weatherburn, Riemannian geometry and The Tensor Calculus, Cambridge, 1938.

B. SPECIAL FUNCTIONS (MDMA 15B)

Unit I: Special functions and multiple Fourier Series:

Orthogonal functions – Bessel functions and Legendre polynomials – Generalized Fourier series expansions of an arbitrary function in terms of orthogonal functions – Bessel functions of order zero and Legendre polynomials – Fourier series expansions of functions of two and three variables.

Chapter: 1.1 – 1.7 **(18 hours)**

Unit II: Boundary Value Problems:

Solutions of one dimensional wave equation – One dimensional heat equation (without derivation) – Fourier series – solutions in Cartesian co-ordinates.

Chapter: 2.1 – 2.4 **(18 hours)**

(18 hours)

Unit III: Partial Differential Equations:

Two dimensional wave equations in rectangular – Cartesian and cylindrical polar coordinate systems — Two dimensional heat flow in transient state both in rectangular and circular plates.

Chapter: 3.1 – 3.3 **(18 hours)**

Unit IV: Partial Differential Equations:

Solutions of wave equation – diffusion equation – Poisson equation and Laplace equation by the method of separation of variables – Transverse vibration of rectangular and circular membranes – Potentials due to charged circular rings – circular plates and spheres.

Chapter: 4.1 – 4.6 **(18 hours)**

Unit V: Laplace Transformations:

Laplace transforms – simple properties – inverse Laplace Transformation – Convolution theorem – application to solution of ordinary differential equations.

Chapter: 5.1 – 5.5 **(18 hours)**

Recommended Text:

- J.N.Sharma and R.K.Gupta (1998) *Special Functions*, Krishna Prakashan Mandir, Meerut.

References :

1. F.B.Hildebrand. (1977) *Advanced Calculus for Applications.* Prentice Hall. New Jersey.
2. Advanced Engineering & Sciences M.K.Venkataraman, The National Publishing Co.
3. Applied Mathematics for Engineers and Physicists, Luis A Pipes and Hartill, McGraw Hill.
4. Engineering Mathematics Series, Veerarajan. T, Tata Mcgraw Hill Publicatin
5. Advanced Engineering Mathematics, Erwin Kreyszing, fifth edition, Wiley Eastern pubishers, 1985.
6. Mathematics For Biological Sciences, Arya. J.C. and R.W Kardber , Prentice Hall International Edn(1979).

C. COMBINATORICS (MDMA 15C)

Unit I: Permutations and Combinations-Generating functions. **(18 Hours)**

Chapter 1 & Chapter 2 of Text Book - I.

Unit II: Recurrence relations. **(18 Hours)**

Chapter 3 of Text Book - I.

Unit III: The principle of inclusion and exclusion. **(18 Hours)**

Chapter 4 of Text Book - I.

Unit IV: Polya's theory of counting. **(18 Hours)**

Chapter 5 of Text Book - I.

Unit V: Lattices and Boolean algebra. **(18 Hours)**

Chapter 6 of Text Book - II.

Recommended Text:

- C.L.Liu, **"Introduction to Combinatorial Mathematics",** McGraw-Hill Book company, 1968.
- Birkhoff and Bartee, **"Modern Applied Algebra",** McGraw Hill Inc., 1970.

References:

- J. H. Van Lint , R. M. Wilson, A Course in Combinatorics, Cambridge University Press, 2001.

D. OPERATIONS RESEARCH (MDMA 15D)

UNIT I: LINEAR PROGRAMMING PROBLEM

Linear Programming Basic Concepts - Convex sets, Linear Programming Problem (LPP). Examples of LPP. Huperplane, Open and closed half - spaces. Feasible, basic feasible and optimal solutions. Extreme point and graphical method.

Chapter: Appendix – $A_1 – A_7$ **(18 hours)**

UNIT II: PROJECT NETWORK SCHEDULING BY PERT AND CPM

Basic differences between PERT and CPM - Steps in PERT / CPM Techniques - PERT / CPM Network components and Precedence Relationships - Critical Path Analysis - Probability in PERT Analysis - Project Time - Cost Trade Off - Updating the Project.

Chapter - 13: 13.2, 13.4, 13.5, 13.7, 13.8. **(18 hours)**

UNIT III: INVENTORY CONTROL MODELS

Meaning of Inventory Control - Functional classification - Advantage of Carrying Inventory - Features of Inventory System - Inventory Model building - Deterministic Inventory Models with or without shortage - Probabilistic Inventory models with or without shortage.

Chapter - 14: 14.2 – 14.6 **(18 hours)**

UNIT IV: QUEUEING MODELS

Essential features of Queueing System - Operating Characteristic of Queueing System - Probabilistic Distribution in Queueing Systems - Classification of Queueing Models - Solution of Queueing Models - Probability Distribution of Arrivals and Departures.

Chapter - 16: 16.2 – 16.7 with Appendix 16.A. **(18 hours)**

UNIT V: REPLACEMENT AND MAINTENANCE MODELS

Replacement models - Items that deteriorate with time - When money value changes - Item that fail completely - Individual replacement and Group replacement.

Chapter - 17: 17.1 – 17.4 **(18 hours)**

Recommended Text:

- J.K.Sharma, Operations Research Theory and Applications, 3rd Edition (2007), Macmillan India Ltd.

Reference Books:

1. Kanti Swarup, Gupta P.K., and Manmohan, (2008), Operations Research, S. Chand & sons.

2. Hamdy A.Taha, Operations Research (6^{th} Edition), Prentice Hall of India Private Limited, New Delhi.

3. S.D.Sharma, Operations Research, Kedamanth Ramnath & Co., 2006.

4. F.S.Hillier and J.Lieberman, Introduction to Operations Research (8^{th} Edition), Tata McGraw Hill Publishing Company, New Delhi, 2006.

E. DISCRETE MATHEMATICS (MDMA 15E)

Unit I:

The Foundations: Logic, Sets and Functions: Logic – Propositional - Equivalences – Predicates and Quantifiers - Sets – Set Operations – Functions – Sequences and Summations – The Growth of Functions.

Chapter 1: 1.1 – 1.9 **(18 Hours)**

Unit II:

The Fundamentals: Algorithms, the Integers, and Matrices Algorithms - Complexity of Algorithms - Integers and Algorithms - Applications of Number Theory - Matrices.

Chapter 2: 2.1 – 2.5 **(18 Hours)**

Unit III:

Mathematical Reasoning: Methods of Proof - Mathematical Induction – Recursive Definitions – Recursive Algorithms -Program Correctness.

Chapter 3: 3.1 – 3.5 **(18 Hours)**

Unit IV:

Relations: Relations and Their Properties – *n*-array Relations and Their Applications – Representing Relations – Closures of Relations – Equivalence Relations – Partial Orderings.

Chapter 6: 6.1 – 6.6 **(18 Hours)**

Unit V:

Trees: Introduction of Trees – Applications of Tress – Tree Traversal – Trees and Sorting – Spanning Tress – Minimum Spanning Trees.

Chapter 8: 8.1 – 8.6 **(18 Hours)**

Text Book:

- Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw – Hill Publications, 1999.

Reference Books:

1. S. Lipschutz, M. Lipson, "**Discrete Mathematics**", Tata McGraw-Hill Publishing Company, New Delhi, 2006.

2. J. Truss, "**Discrete Mathematics for Computer Scientists**", Pearson Education Limited, England, 1999.

3. J. P. Trembley and R. Manohar, **"Discrete Mathematical Structures with Applications to Computer Sciences**", Tata McGraw Hill, Singapore, 1987.

SEMESTER - II
ALGEBRA – II (MDMA 21)
(CORE PAPER – 5)

Unit I: Vector Spaces
Definitions and basic theory – The Matrix of a linear transformation – Dual vector spaces – Determinants. **(18 Hours)**

Chapter 11: 11.1 - 11.4

Unit II: Module over Principal Ideal Domain
Basic definitions and examples – The Basic Theory –The Rational Canonical Form –The Jordan Canonical Form. **(18 Hours)**

Chapter 10: 10.1 & Chapter 12 : 12.1 - 12.3

Unit III: Field theory
Basic Theory of field extensions – Algebraic Extensions. **(18 Hours)**

Chapter 13: 13.1 - 13.2

Unit IV: Field Theory (Cont…)
Splitting fields and Algebraic closures – Separable and inseparable extensions - Cyclotomic polynomials and extensions. **(18 Hours)**

Chapter 13: 13.4 - 13.6

Unit V: Galois Theory
Basic definitions – The fundamental theorem of Galois theory – Finite Fields. **(18 Hours)**

Chapter 14: 14.1 - 14.3

Text Book : David S. Dummit and Richard M. Foote, Abstract Algebra (Second Edition), Wiley, 2003.

References:

1. Serge Lang, Algebra, Springer, 2002.
2. I.N. Herstein. Topics in Algebra (II Edition) Wiley Eastern Limited, New Delhi, 1975.
3. M.Artin, Algebra, Prentice Hall of India, 1991.
4. N.Jacobson, Basic Algebra, Vol. I & II W.H.Freeman; also published by Hindustan Publishing Company, New Delhi, 1980.
5. I.S.Luther and I.B.S.Passi, Algebra, Vol. I - Groups (1996); Vol. II *Rings*, Narosa Publishing House , New Delhi, 1999.
6. Joseph A. Gallian, Contemporary Abstract Algebra, Brooks / Cole Pub Co., 2012.

REAL ANALYSIS – II (MDMA 22)
(CORE PAPER – 6)

Unit I: Infinite series and Infinite products

Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series - Cesaro summability - Infinite products.

Chapter 8: 8.20 – 8.26 **(18 Hours)**

Unit 2: Sequence of Functions

Point-wise convergence of sequences of functions - Examples of sequences of real-valued functions - Definition of uniform convergence - Uniform convergence and continuity - The Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions.

Chapter 9: 9.1 – 9.6 **(18 Hours)**

Unit 3: Sequence of Functions [Continued]

Uniform convergence and Riemann-Stieltje's integration – Non-uniformly convergent sequences that can be integrated term by term - Uniform convergence and differentiation - Sufficient conditions for uniform convergence of a series - Uniform convergence and double sequences - Mean convergence.

Chapter 9: 9.8 – 9.13 **(18 Hours)**

Unit 4: Multi-Variable Differential Calculus

Introduction - The differential derivative - Directional derivatives and continuity – The total derivative - The total derivative expressed in terms of partial derivatives - An application to complex-valued functions - The matrix of a linear function - The Jacobian matrix - The chain rule.

Chapter 12: 12.1 – 12.9 **(18 Hours)**

Unit 5: Implicit functions and Extremum problems

Introduction - Functions with non-zero Jacobian determinant - The inverse function theorem - The implicit function theorem.

Chapter 13: 13.1 – 13.4 **(18 Hours)**

Recommended Text Book:

- Tom M. Apostal, "**Mathematical Analysis**" Addison-Wesley Publishing Company, 1974.

References:

1. Walter Rudin, "**Principles of Mathematical Analysis**", Mc Graw Hill Inc, 1964.
2. Anthony W. Knapp, "**Basic Real Analysis"**, Birkhauser, 2005.
3. Dieudome, J., "**Foundations of Modern Analysis"**, Academic press, Inc, Newyork, 1960.

PARTIAL DIFFERENTIAL EQUATIONS (MDMA 23)
(CORE PAPER – 7**)**

UNIT - I: PARTIAL DIFFERENTIAL EQUATIONS OF FIRST ORDER

Formation and solution of PDE- Integral surfaces - Cauchy Problem order equation - Orthogonal surfaces - First order non-linear - Characteristics - Compatible system – Charpit's method.

Chapter 0: 0.4 to 0.11 (omit 0.1, 0.2, 0.3 and 0.11.1) **(18 Hours)**

UNIT - II: FUNDAMENTALS

Introduction - Classification of Second order PDE - Canonical forms – Adjoint operators - Riemann's method.

Chapter 1: 1.1 to 1.5 **(18 Hours)**

UNIT - III: ELLIPTIC DIFFERENTIAL EQUATIONS

Derivation of Laplace and Poisson equation - BVP - Separation of Variables - Dirichlet's Problem and Newmann Problem for a rectangle - Solution of Laplace equation in Cylindrical and spherical coordinates - Examples.

Chapter 2: 2.1, 2.2, 2.5 to 2.7, 2.10 to 2.13(omit 2.3, 2.4, 2.8 and 2.9) **(18 Hours)**

UNIT - IV: PARABOLIC DIFFERENTIAL EQUATIONS

Formation and solution of Diffusion equation – Dirac - Delta function - Separation of variables method - Solution of Diffusion Equation in Cylindrical and spherical coordinates - Examples.

Chapter 3: 3.1 to 3.7 and 3.9. (omit 3.8) **(18 Hours)**

UNIT - V: HYPERBOLIC DIFFERENTIAL EQUATIONS

Formation and solution of one-dimensional wave equation - canonical reduction – IVP - D'Alembert's solution - IVP and BVP for two-dimensional wave equation - Periodic solution of one-dimensional wave equation in cylindrical and spherical coordinate systems - Uniqueness of the solution for the wave equation - Duhamel's Principle - Examples.

Chapter 4: 4.1 to 4.12 (omit 4.5, 4.6 & 4.10) **(18 Hours)**

Recommended Text:

- K. Sankar Rao, *Introduction to Partial Differential Equations*, 2nd Edition, Prentice Hall of India, New Delhi. 2005

Reference Books:

1. R.C.McOwen, *Partial Differential Equations*, 2nd Edn. Pearson Eduction, New Delhi, 2005.
2. I.N.Sneddon, *Elements of Partial Differential Equations*, McGraw Hill, New Delhi, 1983.
3. R. Dennemeyer, *Introduction to Partial Differential Equations and Boundary Value Problems,* McGraw Hill, New York, 1968.
4. M.D.Raisinghania, *Advanced Differential Equations,* S.Chand & Company Ltd., New Delhi, 2001.

TOPOLOGY (MDMA 24)
(CORE PAPER – 8)

Unit I: Topological Spaces

Topological Spaces - Examples– Basis for a topology – Sub-basis – closed sets –interior – closure - boundary – Limitpoints – Hausdorff spaces – Subspace topology – The product topology on $X \times Y$ - Projections.

Chapter 2: Section: 12 - 17 **(18 Hours)**

Unit II: Continuous Functions

Continuous functions–Examples–Homeomorphisms – topological property – pasting lemma – the product topology – Box topology - Comparison of the product topology and the box topology – the metric topology – Sequence Lemma – Uniform Limit theorem.

Chapter 2: Section: 18 - 21 **(18 Hours)**

Unit III: Connected Spaces

Connected Spaces– connected subspace of the real line – Linear continuum –Intermediate Theorem – components and Local connectedness – Totally disconnected spaces.

Chapter 3: Section: 23 - 25 **(18 Hours)**

Unit IV: Compact Spaces

Compact Spaces - Compact subspace of the real line – The Lebesque number lemma – Uniform continuity theorem – Limit point compactness – Local compactness – one point compactification.

Chapter 3: Section: 26 - 29 **(18 Hours)**

Unit V: Countability and Separation Axioms

First countable and second countable spaces – separation axioms – regular and completely regular spaces– Normal and completely Normal spaces – Urysohn's lemma – Urysohn's metrization theorem – Tietze Extension theorem.

Chapter 4: Section: 30 - 35 **(18 Hours)**

Text Book:

- James R. Munkres, "Topology", 2nd Edition, Prentice Hall of India Pvt.Ltd., (Third Indian Reprint).

References :

1. J.Dugundji, Topology, Prentice Hall of India, New Delhi, 1975.

2. George F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill International Edition, New York, 1963.

3. J.L.Kelly, General Topology, Van Nostrand , Reinhold co., New York.

4. K.D.Joshi, Introduction to General Topology, Wiley Eastern Ltd., 1983.

5. C.Wayne Patty, Foundations of Topology, (Student Edition), Jones & Bartlett India Pvt.Ltd., New Delhi.

6. Colin Adams, Robert Franzosa, Introduction to Topology Pure and Applied, Pearson Education, Indian Edition, 2009.

ELECTIVE - II
A. FUZZY MATHEMATICS (MDMA 25A)

Unit I: Fuzzy Sets

Fuzzy sets – Basic types – basic concepts – Characteristics – Significance of the paradigm shift – Additional properties of α–cuts.

Chapter 1: 1.3 - 1.5 and **Chapter 2:** 2.1 **(18 Hours)**

Unit II: Fuzzy sets versus CRISP sets

Representation of fuzzy sets – Extension principle of fuzzy sets – Operation on fuzzy sets – Types of operation – Fuzzy Complements.

Chapter 2: 2.2 - 2.3 and **Chapter 3:** 3.1 - 3.2 **(18 Hours)**

Unit III: Operations on Fuzzy sets

Fuzzy intersection – t-norms, fuzzy unions – t-conorms – Combinations of operations – Aggregation operations.

Chapter 3: 3.3 - 3.6 **(18 Hours)**

Unit IV: Fuzzy Arithmetic

Fuzzy numbers – Linguistic variables – Arithmetic operation on intervals – Lattice of fuzzy numbers.

Chapter 4: 4.1 - 4.4 **(18 Hours)**

Unit V: Constructing Fuzzy Sets

Methods of construction on overview – direct methods with one expert – direct method with multiple experts – indirect method with multiple experts and one expert – Construction from sample data.

Chapter 10: 10.1 - 10.7 **(18 Hours)**

Text Book:

- G.J Kilr and Bo Yuan, Fuzzy sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India Ltd, New Delhi, 2005.

References:

1. H.J Zimmemann, Fuzzy Set Theory and its Applications, Allied Publishers, Chennai, 1996.
2. A.Kaufman, Introduction to the Theory of fuzzy subsets, Academic press, New York, 1975.
3. V.Novak, Fuzzy Sets and Their Applications, Adam Hilger, Bristol, 1969.

B. BIO-MATHEMATICS (MDMA 25B)

Unit I: Single species Non-age structured population Models: Single. Logistic Models- Logistic Models with Time-Delay effects- Discrete-Time. Discrete-Age-scale population models- Continuous-Time Discrete. Age scale population Models. **(18 Hours)**

Chapter: 3.1 - 3.2 & 4.1 - 4.2

Unit II: Epidemic models: Deterministic models without removal, general deterministic model with removal, general deterministic model with removal and immigration, control of an epidemic. **(18 Hours)**

Chapter: 8.1 - 8.4

Unit III: Models for Blood Flow: Some basic concepts for fluid dynamics, basic concepts about blood, cardiovascular system and blood flows, steady non-Newtonian fluid flow in circular tubes, Newtonian pulsatile flows in rigid and elastic tubes, blood flow through artery with mild stones.

Chapter: 11.1 – 11.5 **(18 Hours)**

Unit IV: Models of flows for other Bio-fluids:

Peristaltic flow in tubes and channels, models for gas exchange and air flow in lungs, Two-dimensional flow in renal tubule, lubrication of Human joints. **(18 hours)**

Chapter: 12.1 – 12.3

Unit V: Diffusion and Diffusion-Reaction Models: The Diffusion Equation – Diffusion in Artificial Kidney (Hemodialyser) – Oxygen Diffusion through Living Tissues. **(18 hours)**

Chapter: 13.1 – 13.3

Text Book:

- Mathematical Modelling in Biology Medicine: J.N. Kapoor

References:

(1) Mathematical Modelling: J.N. Kapoor.

(2) Mathematical Biology: J.D. Murty.

(3) Ecology and Resource Management: K.E.F. Watt.

C. STOCHASTIC DIFFERENTIAL EQUATIONS (MDMA 25C)

Unit I: Mathematical Preliminaries and Itô Integrals

Probability Spaces – Random variables and Stochastic Processes – An Important Example: Brownian motion – Construction of the Itô Integral – Some Properties of the Itô Integral – Extensions of the Itô Integral.

Chapter 2: 2.1 - 2.2 and **Chapter 3:** 3.1 - 3.3 **(18 Hours)**

Unit II: Itô Formula and Martingale Representation Theorem

The 1 - dimensional Itô Formula - The Multi-dimensional Itô Formula – The Martingale Representation Theorem.

Chapter 4: 4.1 - 4.3 **(18 Hours)**

Unit III: Stochastic Differential Equations

Examples and Some Solution Methods – An Existence and Uniqueness Result – Weak and Strong Solutions.

Chapter 5: 5.1 - 5.3 **(18 Hours)**

Unit IV: The Filtering Problem

Introduction – The 1-Dimensional Linear Filtering Problem – The Multidimensional Linear Filtering Problem.

Chapter 6: 6.1 - 6.3 **(18 Hours)**

Unit V: Diffusions: Basic Properties

The Markov Property – The Strong Markov Property – The Generator of an Itô Diffusion – The Dynkin Formula – The Characteristic Operator.

Chapter 7: 7.1 - 7.5 **(18 Hours)**

Text Book :

- B. Oksendal, Stochastic Differential Equations: An Introduction with Applications, Sixth Edition, Springer - Verlag, Heidelberg, 2003.

References:

1. Avner Friedman, Stochastic Differential Equations and Application, Dover Publications, 2006.
2. Ludwig Arnold, Stochastic Differential Equations: Theory and Applications, Dover Publications, 2011.
3. Hui-Hsiung Kuo, Introduction to Stochastic Integration, Springer-Verlag, 2006
4. Douglas Henderson and Peter Plaschko, Stochastic Differential Equations in Science and Engineering, World Scientific, 2006.

D. CRYPTOGRAPHY AND DATA SECURITY (MDMA 25D)

Unit I: Some Topics in Elementary Number Theory

Time estimates for doing arithmetic – Divisibility and the Euclidean algorithm – Congruences.
Chapter 1: Sections 1,2 and 3 **(18 Hours)**

Unit II: Finite Fields and Quadratic Residues

Some applications to factoring – Quadratic residues and reciprocity.
Chapter 1: Section 4 and C**hapter 2:** Section 2 **(18 Hours)**

Unit III: Cryptography

Some simple Cryptosystems – Enciphering matrices.
Chapter 3 **(18 Hours)**

Unit IV: Public Key

The idea of public key cryptography – RSA – Discrete log – Knapsack – Zero- Knowledge protocols and oblivious transfer.
Chapter 4 Section 1 – 4. **(18 Hours)**

Unit V: Primality and Factoring

Pseudo primes – The rho method – Fermat factorization and factor bases – The continued fraction method – The quadratic sieve method.
Chapter 5 **(18 Hours)**

Text Book:

- Neal Koblitz, "A Course in Number Theory and Cryptography"- Second Edition, Springer Publishers.

References:

1. A.Menezes, P. van Oorschot and S. Vanstone, "Handbook of Applied Cryptography", CRC press, 1996.
2. Douglas R. Stinson "Cryptography theory and practice" Second Edition, Chapman and Hall / CRC.
3. Tom. M. Apostol**, "Introduction to Analytic Number Theory**", Springer, New Delhi, 1993.

HUMAN RIGHTS (MDHR 20)

(COMPULSORY PAPER)

Unit I:

Definition of Human Rights – Nature, Content, Legitimacy and Priority – Theories on Human Rights – Historical Development of Human Rights.

Unit II:

International Human Rights – Prescription and Enforcement upto World War II – Human Rights and the U.N.O. – Universal Declaration of Human Rights – International Covenant on Civil and Political Rights – International Covenant on Economic, Social and Cultural Rights and Optional Protocol.

Unit III:

Human Rights Declarations – U.N. Human Rights Declarations – U.N. Human Commissioner.

Unit IV:

Amnesty International – Human Rights and Helsinki Process – Reginal Developments – European Human Rights System – African Human Rights System – International Human Rights in Domestic Courts.

Unit V:

Contemporary Issues on Human Rights: Children's Rights – Women's – Dalit's Rights – Bonded Labour and Wages – Refugees – Capital Punishment - Fundamental Rights in the Indian Constitution- Directive Principles of State Policy – Fundamental Duties – National Human Rights Commission.

References :

1. International Bill of Human Rights, Amnesty International Publication, 1988.
2. Human Rights, Questions and Answers, UNESCO, 1982.
3. Mausice Cranston – What is Human Rights.
4. Desai, A.R. - Violation of Democratic Rights in India.
5. Pandey - Constitutional Law.

6. Timm. R.W. - Working for Justice and Human Rights.
7. Human Rights, A Selected Bibliography, USIS.
8. J.C.Johari - Human Rights and New World Order.
9. G.S. Bajwa - Human Rights in India.
10. Amnesty International, Human Rights in India.
11. P.C.Sinha&K.Cheous [Ed] - International Encyclopedia of Peace, Security Social Justice and Human Rights [Vols 1-7].
12. Devasia, V.V. - Human Rights and Victimology.

Magazines :

1. The Lawyer, Bombay.
2. Human Rights Today, Columbia University.
3. International Instruments of Human Rights, UN Publication.
4. Human Rights Quarterly, John Hopkins University, U.S.A.

SEMESTER III
FUNCTIONAL ANALYSIS (MDMA 31)
(CORE PAPER – 9)

UNIT I: BANACH SPACES

Banach spaces - Definition and examples - Continuous Linear Transformations – Hahn Banach Theorem.
Chapter 9: Sections 46 to 48 **(18 Hours)**

UNIT II: BANACH SPACES AND HILBERT SPACES

The natural embedding of N in N** - Open mapping theorem - Conjugate of an operator – Hilbert space - Definition and properties.
Chapter 9: Sections 49 to 51; **Chapter 10:** Sections 52. **(18 Hours)**

UNIT III: HILBERT SPACE

Orthogonal complements - Orthonormal sets - Conjugate space H* - Adjoint of an operator.
Chapter 10: Sections 53 to 56. **(18 Hours)**

UNIT IV: OPERATIONS ON HILBERT SPACES

Self - adjoint operator - Normal and Unitary Operators – Projections.
Chapter 12: Sections 57 to 59. **(18 Hours)**

UNIT V: BANACH ALGEBRAS

Banach Algebras - Definition and examples - Regular and simgle elements - Topological divisors of zero - spectrum - the formula for the spectral radius - the radical and semi-simplicity.
Chapter 12: Sections 64 to 69. **(18 Hours)**

Recommended Text:

- G.F.Simmons, Introduction to topology and Modern Analysis, McGraw Hill International Book Company, New York, 1963.

Reference Books:

1. W. Rudin *Functional Analysis*, Tata McGraw-Hill Publishing Company, New Delhi, 1973.
2. H.C. Goffman and G. Fedrick, *First Course in Functional Analysis*, Prentice Hall of India, New Delhi, 1987.
3. Bela Bollobas, *Linear Analysis an introductory course*, Cambridge Mathematical Text books, Cambridge University Press, 1990.
4. D. Somasundaram, *Functional Analysis*, S. Viswanathan Pvt. Ltd., Chennai, 1994.
5. G. Bachman & L.Narici, *Functional Analysis* Academic Press, New York, 1966.
6. E. Kreyszig *Introductory Functional Analysis with Applications*, John wiley & Sons, New York.,1978.

COMPLEX ANALYSIS (MDMA 32)

(CORE PAPER – 10**)**

Unit I: Complex Functions

Spherical representation of complex numbers - Analytic functions - Limits and continuity - Analytic Functions - Polynomials - Rational functions - Elementary Theory of Power series - Sequences - Series - Uniform Convergence - Power series - Abel's limit functions - Exponential and Trigonometric functions - Periodicity - The Logarithm.

Chapter 1: 1.2 & 1.4 and **Chapter 2:** 2.1 – 2.3 **(18 Hours)**

Unit II: Analytical functions as mappings

Conformality - Arcs and closed curves - Analytic functions in Regions - Conformal mapping - Length and area - Linear transformations - Linear group - Cross ratio - symmetry - Oriented Circles - Families of circles - Elementary conformal mappings - Use of level curves - Survey of Elementary mappings - Elementary Riemann surfaces.

Chapter 3: 3.2 – 3.4 **(18 Hours)**

Unit III: Complex Integration

Fundamental Theorems - Line Integrals – Rectifiable Arcs- Line Integrals as Arcs- Cauchy's Theorem for a rectangle and in a disk- Cauchy's Integral Formula – Index of point with respect to a closed curve – The Integral formula – Higher order derivatives – Local properties of analytic functions – Taylor's Theorem – Zeros and Poles – Local mapping – Maximum Principle.

Chapter 4: 4.1 – 4.3 **(18 Hours)**

Unit IV: Complex Integration (Contd…)

The General form of Cauchy's Theorem - Chains and Cycles – Simple connectivity – Homology – General statement of Cauchy's theorem – Proof of Cauchy's theorem – Locally exact differentials - Multiply connected regions – Calculus of residues – Residue Theorem – Argument Principle – Evaluation of definite Integrals.

Chapter 4: 4.4 – 4.5 **(18 Hours)**

Unit V: Harmonic functions and Power Series expansions

Harmonic Functions – Definition and basic properties – Mean-value Property – Poisson's formula – Schwarz's Theorem – Reflection Principle – Weierstrass's theorem – Taylor's series- Laurent series.

Chapter 4: 4.6 and **Chapter 5:** 5.1 **(18 Hours)**

Text Book:

- Complex Analysis" by L.V. Ahlfors, Third Edition, McGraw Hill, New York, 1979.

References:

1. J.B. Conway, Functions of One Complex Variable, Narosa Publication House, New Delhi, 1980.
2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publication House, New Delhi 2004.
3. S. Lang, Complex Analysis, Addison - Wesley Mass, 1977.

FLUID DYNAMICS (MDMA 33)
(CORE PAPER – 11**)**

Unit I: Kinematics of fluids in motion

Real fluids and ideal fluids - velocity of a fluid at a point - stream lines and path lines - steady and unsteady flows - the velocity potential - the vorticity vector - local and particle rates of change - the equation of continuity - worked examples.

Chapter 2: 2.1 – 2.8 **(18 Hours)**

Unit II: Equation of motion of fluid

Pressure at a point in fluid at rest - Pressure at a point in a moving fluid - conditions at a boundary of two inviscid immiscible fluids - Euler's equation of motion - Bernoulli's equation – worked examples.

Chapter 3: 3.1 – 3.6 **(18 Hours)**

Unit III: Some three dimensional flows

Introduction – sources – sinks and doublets – Axis symmetric flow – Stokes stream function.

Chapter 4: 4.1 - 4.2 & 4.5 **(18 Hours)**

Unit IV: Some two dimensional flows

Meaning of two dimensional flows – use of cylindrical polar coordinates – the stream function – the potential for two dimensional – irrotational – incompressible flows – complex velocity potential for standard two dimensional flows – the Milne-Thomson circle theorem with examples.

Chapter 5: 5.1 – 5.5 and 5.8 **(18 Hours)**

Unit V: Boundary Value Problems: Solutions of one dimensional wave equation – One dimensional heat equation (without derivation) – Fourier series – solutions in Cartesian co-ordinates. **(18 hours)**

Text Book:

- F. Chorlton, **Text book of Fluid Dynamics,** CBS Publication, New Delhi, 1985.
- M.K.Venkataraman, **Advanced Engineering & Sciences,** The National Publishing Co.

References:

1. G.K.Batchelor, An Introduction of Fluid Mechanics, Foundation Books, New Delhi, 1993.
2. A.R.Paterson, A First Course in Fluid Dynamics, Cambridge University Press, New York, 1987.
3. R.K.Rathy, An Introduction to Fluid Dynamics, IBH Publishing Company, New Delhi, 1976.
4. R.Von Mises, O.Friedrichs, Fluid Dynamics, Springer International Student Edition, Narosa Publishing House, New Delhi.
5. S.W.Yuan, Foundation of Fluid Mechanics, Prentice Hall Private Ltd, New Delhi, 1976.

APPLIED PROPBABILITY AND STATISTICS (MDMA 34)
(CORE PAPER – 12**)**

Unit I: RANDOM VARIABLES
Random variables - the concept of a random variable - distribution and density functions - random variables of the discrete and continuous type - joint distribution and joint density functions - marginal distribution - conditional distribution - co-variance – correlation - mathematical expectation - Moment generating function - characteristic function.

Chapter 1 & **2 (1.1 – 1.7, 2.1 – 2.9):** M. Fisz, Probability theory and Mathematical Statistic, John Willey and sons, Newyork, 1963.

Unit II: SOME PROBABILITY DISTRIBUTIONS
Binomial and Poisson distributions - Normal distribution - Gamma and Exponential distribution - Weibull distribution - Regression and Correlation - Partial and Multiple Correlation - Multiple regression.

Chapter – 4 (4.1 - 4.7): M. Fisz, Probability theory and Mathematical Statistic, John Willey and sons, Newyork, 1963.

Unit III: TESTING OF HYPOTHESIS
Estimation and procedure of testing of hypothesis - Large sample tests - Small sample tests - student's t-test - F-test - Chi-square test - Testing of mean, variance and proportions - independence of attributes and goodness of fit.

Chapter 4 & Chapter 5 of M. Fisz, Probability theory and Mathematical Statistic, John Willey and sons, Newyork, 1963.

Unit IV: DESIGN OF EXPERIMENTS
Analysis of variance - One way and two way classifications - completely Random Design (CRD) - Randomized Block Design (RBD) - Latin Square Design (LSD).

Chapter 10: Kishore S. Trivedi, Probability & Statistics with Reliability, queuing and computer Science applications, Prentice Hall of India, Pvt. Ltd., New Delhi (2009).

Unit V: RELIABILITY
Basic concept-Reliabilities of series and parallel systems-System Reliability-Hazard function-Reliability and Availability-Maintainability.

Chapter 15 & 16 (15.1 - 15.2, 16.1 - 16.5) Kishore S. Trivedi, Probability & Statistics with Reliability, queuing and computer Science applications, Prentice Hall of India, Pvt. Ltd., New Delhi (2009).

Text Books:

- R.E.Walpole, R.H.Mayers, S.L.Mayers and K.Ye, Probability and Statistics for engineers and scientists, 7th Edition, Pearson Education (2003).

- Kishore S. Trivedi, Probability & Statistics with Reliability, queuing and computer Science applications, Prentice Hall of India, Pvt. Ltd., New Delhi (2009).

Reference:

1. J.L.Devore, Probability and Statistics, 5th Edition, Thomson (2000).
2. R.A.Johnson, Miller & Freund's Probability and Statistics for Engineers, Seventh edition, Pearson Education, New Delhi (2008).
3. Gupta S.C. and Kapoor V.K., Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 11th Edition, 2003.

ELECTIVE – III

A. FINANCIAL MATHEMATICS (MDMA 35A)

Unit I: Generalized Cash Flow model for financial transaction, making allowance for the probability of payment, Time value of money using concepts of compound interest and discounting, Interest rates or discount rates in terms of different time periods. **(18 Hours)**

Unit II: Calculation of the present value and the accumulated value of a stream of equal or unequal payments using specified rates of interest and the net present value at a real rate of interest, assuming a constant rate of inflation. **(18 Hours)**

Unit III: Use of compound interest function, Equation of value, Repayment by regular installments of interest and capital, discounted cash flow techniques. **(18 Hours)**

Unit IV: The investments and risk characteristics of the following types: Simple compound interest problems. The delivery price and the value of the forward contract using arbitrage free pricing methods. **(18 Hours)**

Unit V: Basics of Reliability theory – Life time distributions – Hazard rate survival function – Exponential, Wei-bull-Gamma, Life Time Distributions. **(18 Hours)**

Recommended Text Book:

- Suresh Chandra (1998), Introductory Financial Mathematics, Narosa Publishers, New Delhi. (for unit 1 - 4).
- S.K. Sinha (1979), Reliability and Life – Testing, Wiley Eastern, New Delhi. (for unit-5).

B. MATHEMATICAL MODELLING (MDMA 35B)

Unit I: Mathematical modeling through system of ordinary differential equations of the first order: Mathematical modeling in population dynamics, Mathematical modeling of epidemics through system of ordinary differential equations of first order- Mathematical modeling in dynamics through systems of ordinary differential equations of first order. **(18 Hours)**

Chapter 3: 3.1 - 3.2 & 3.5 - 3.6 of J.N. Kapoor, Mathematical Modelling, Wiley Eastern Limited, Reprint- 2000.

Unit II: Mathematical Models for Blood flows: Some basic concepts of Fluid Dynamics- Basic concepts about blood, cardiovascular system and Blood flows- Steady Non-Newtonian fluid flows in circular tubes- Newtonian pulsatile flows in rigid and elastic tubes- Blood flow through Artery with mild Stenosis. **(18 Hours)**

Chapter 11: 11.1 - 11.5 of J.N. Kapoor, Mathematical Models in Biology and Medicine, Affiliated East – West Press Private limited, Reprint – 2010.

Unit III: Mathematical Models of flows for other Bio-fluids: Peristaltic flows in tubes and channels- Models for gas exchange and airflow in lungs – Two-dimensional flow in renal tube – Lubrication of Human joints. **(18 Hours)**

Chapter 12: 12.1 - 12.4 of J.N. Kapoor, Mathematical Models in Biology and Medicine, Affiliated East – West Press Private limited, Reprint – 2010.

Unit IV: Diffusion and Diffusion – Reaction Models: The Diffusion equation – Diffusion in Artificial Kidney (Hemodialyser) – Oxygen diffusion through living tissues – Absorption and Diffusion of Gamma- Globulin by living tissues. **(18 Hours)**

Chapter 13: 13.1 - 13.4 of J.N. Kapoor, Mathematical Models in Biology and Medicine, Affiliated East – West Press Private limited, Reprint – 2010.

Unit V: Mathematical Modelling through Calculus of Variations and Dynamic Programming: Optimization principles and techniques – Mathematical modeling through calculus of variations – Mathematical Modelling through dynamic programming. **(18 Hours)**

Chapter 9: 9.1 - 9.3 of J.N. Kapoor, Mathematical Modelling, Wiley Eastern Limited, Reprint- 2000.

C. APPLIED ALGEBRA (MDMA 35C)

Unit I: Boolean Algebras and Switching Circuits
Boolean Algebras- Switches and Logic Gates- Laws of Boolean Algebra- Boolean Polynomials and Boolean Functions- Switching Circuits and Gate Networks- Simplification of Circuits- Designing Circuits- Bridge Circuits.

Chapter 1: 1.1 - 1.8 **(18 Hours)**

Unit II: Balanced Incomplete Block Designs
Basic Definitions and Results - Incidence Matrix of a BIBD-Construction of BIBDs from Difference Sets- Construction of BIBDs Using Quadratic Residues - Difference SetFamilies- Construction of BIBDs from Finite Fields- Construction of BIBDs from Nearrings- Planar Nearrings- Finite Integral Planar Nearrings and BIBDs - Finite Fields and Planar Nearrings.

Chapter 2: 2.1 – 2.10 **(18 Hours)**

Unit III: Algebraic Cryptography
Substitution Ciphers - Algebraic Enciphering Algorithms and Classical Cryptosystems - Block Ciphers and Advanced Encryption Standard- Public-Key Cryptosystems.

Chapter 3: 3.1 – 3.4 **(18 Hours)**

Unit IV: Coding Theory
Introduction to Error-Correcting Codes- Linear Codes- Cyclic Codes- BCH Codes.

Chapter 4: 4.1 - 4.4 **(18 Hours)**

Unit V: Symmetry Groups and Color Patterns
Permutation Groups- Groups of Symmetries- Colorings and Patterns- Action of a Group on a Set- Burnside Theorem and Color Patterns.

Chapter 5: 5.1 – 5.5 **(18 Hours)**

Text Book:

- S. R. Nagpaul, S. K. Jain-Topics in Applied Abstract Algebra-American Mathematical Society (2004)

References:

1. R.E. Klima,N. Sigmon, E. Stitzinger-Application of Abstract Algebra with MAPLE-CRC Press(1999).
2. Rudolf Lidl, Gunter Pilz – Applied Abstract Algebra-Springer (1997).
3. M.R. Adhikari, A.Adhikari- Basic modern Algebra with Applications-Springer(2014).
4. T.W.Judson –Abstract Algebra Theory and Applications (1997).
5. D.Joyner,R. Kreminski, J.Turisco -Applied Abstract Algebra(2003).

D. APPLIED STATISTICAL METHODS (MDMA 35D)

Unit I: INTRODUCTION TO STATISTICS AND DATA COLLECTION

Collection – classification and tabulation of data – graphical and diagrammatic representation – Bar diagram – Pie diagram – Histogram – Frequency polygon – frequency curve and Ogives.

(18 Hours)

Unit II: DESCRIBING BUSINESS DATA

Measures of central tendency – Mean – Median and Mode in series of individual observations, Discrete series – Continuous series (inclusive) – More than frequency – less than frequency – Mid-value and open-end class. **(18 Hours)**

Unit III: DESCRIBING DATA MEASURES

Measures of dispersion – Range, Quartile deviation, Mean deviation about an average, Standard deviation and co-efficient of variation for individual, discrete and continuous type data.

(18 Hours)

Unit IV: CORRELATION ANALYSIS

Correlation – different types of correlation – positive, negative, simple, partial, multiple, linear and non-linear correlation. Methods of correlation – Karl Pearson's Spearman's correlations and concurrent deviation. **(18 Hours)**

Unit V: REGRESSION ANALYSIS

Regression types and method of analysis, regression line, regression equations, deviation taken from arithmetic mean of X and Y, deviation taken from assumed mean, partial and multiple regression coefficients – applications. **(18 Hours)**

Recommended Text Book:

- S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and sons, New Delhi, 1994.

References:

1. Freund J.E. (2001); Mathematical Statistics, Prentice Hall of India.
2. Goon A.M., Gupta M.K., Dos Gupta B., (1991), Fundamentals of Statistics, Vol. 1, World press, Calcutta.

E. STABILITY THEORY (MDMA 35E)

Unit I: Observability:
Linear Systems – Observability Grammian – Constant coefficient systems – Reconstruction kernel – Nonlinear Systems.
Chapter 2 **(18 Hours)**

Unit II: Controllability:
Linear systems – Controllability Grammian – Adjoint systems – Constant coefficient systems – Steering function – Nonlinear systems.
Chapter 3: Sections 3.1-3.3 **(18 Hours)**

Unit III: Stability:
Stability – Uniform stability – Asymptotic stability of linear systems - Linear time varying systems – Perturbed linear systems – Nonlinear systems.
Chapter 4 **(18 Hours)**

Unit IV: Stabilizability:
Stabilization via linear feedback control – Bass method – Controllable subspace – Stabilization with restricted feedback.
Chapter 5 **(18 Hours)**

Unit V: Optimal Control:
Linear time varying systems with quadratic performance criteria – Matrix Riccati equation – Linear time invariant systems – Nonlinear Systems.
Chapter 6 **(18 Hours)**

Text Book:

- **K.Balachandran** and **J.P.Dauer**, *Elements of Control Theory*, Narosa, New Delhi, 1999.

Books for Supplementary Reading and Reference:

1. R.Conti, *Linear Differential Equations and Control*, Academic Press, London, 1976.
2. R.F.Curtain and A.J.Pritchard, *Functional Analysis and Modern Applied Mathematics*, Academic Press, New York, 1977.
3. J.Klamka, *Controllability of Dynamical Systems*, Kluwer Academic Publisher, Dordrecht, 1991.
4. J.Klamka, *Controllability of Dynamical Systems*, Kluwer Academic Publisher, Dordrecht, 1991.

SEMESTER IV
APPLIED NUMERICAL ANALYSIS (MDMA 41)
(CORE PAPER – 13**)**

Unit I: ALGEBRA AND TRANSCENDENTAL SYSTEM OF EQUATIONS

General iterative method - Bisection method - Secant method – Newton - Raphson method - solution of system of equations - Gaussian elimination method - Gauss Jordan method - LU decomposition method - Rate of convergence Gauss - seidel method - Eigen value of a Matrix - Power method - Jacobi method**.**

Text Book 1: Chapter 2: 2.3 - 2.4 & 2.10 - 2.11 **(18 Hours)**

Unit II: INTERPOLATION

Interpolation with equal intervals - Newton's forward and backward formula - Central difference interpolation formula - Gauss forward and backward formula - Sterling's formula - Bessel's formula - Interpolation with unequal intervals - Lagrange's interpolation and inverse interpolation formula - Newton's divided difference formula - Interpolation with cubic spline.

Text Book 1: Chapter 3: 3.2 - 3.4 & 3.7 and **Chapter 4:** 4.1 **(18 Hours)**

Unit III: NUMERICAL DIFFERENTIATION AND INTEGRATION

Numerical differentiation - Formulae for derivatives - Maxima and minima of a tabulated function - Numerical Integration - Trapezoidal rule - Simpson's $1/_{3rd}$ and $3/_{8th}$ rules - Romberg's method - Applications.

Text Book 1: Chapter 5: 5.2, 5.4 & 5.6 - 5.7 **(18 Hours)**

Unit IV: ORDINARY DIFFERENTIAL EQUATIONS

First order equations - System of equations and higher order equations - Taylor series method - Euler method - Modified and Improved Euler's method - Runge kutta methods - Fourth order Runge kutta method - Multi step methods: Adams - Bash forth and Milne's methods - Linear two point Boundary value problems: The shooting method.

Text Book 1: Chapter 6: 6.2 - 6.4 & 6.6 - 6.7. **(18 Hours)**

Unit V: PARTIAL DIFFERENTIAL EQUATIONS

Difference Quotients - classification of partial differential equations - Elliptic equation - Laplace equation by Liebmann's iteration process - Poisson's equations - Parabolic equations - Schmidt explicit formula – Crank-Nicolson method - Hyperbolic equations - Solution of two dimensional heat equations.

Text Book 2: Chapter 12: 12.1 - 12.7, 12.8.2 & 12.9 **(18 Hours)**

Text Books:

1. M.K.Jain, S.R.K.Iyengar and R.K.Jain, Numerical methods for Scientific and Engineering, New Age International Ltd., 5th Edition (2010).
2. B.S.Grewal, J.S.Grewal, Numerical methods in Engineering and Science, Khanna Publishers, New Delhi, 1999.

References:

1. S.S.Sastry, Introductory methods of Numerical Analysis, Prentice Hall of India Pvt.Ltd., New Delhi (2003).
2. M.K.Venkatraman, Numerical methods in Science and technology, National Publishers Company, 1992.
3. P.Kandasamy, K.Thilagavathy and K.Gunavathy, Numerical methods, S.Chand and Company, New Delhi, 2003.

CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS(MDMA 42)
(CORE PAPER - 14)

Unit I: Variational problems with fixed boundaries

The concept of variation and its properties – Euler's equation – Variational problems for Functionals – Functionals dependent on higher order derivatives – Functions of several independent variables – Some applications to problems of Mechanics.

Chapter 1: 1.1 - 1.7 (Text Book - 1) **(18 Hours)**

Unit II: Variational problems with moving boundaries

Movable boundary for a functional dependent on two functions – one-sided variations – Reflection and Refraction of extremals – Diffraction of light rays.

Chapter 2: 2.1 - 2.5 (Text Book - 1) **(18 Hours)**

Unit III: Integral Equation

Introduction – Types of Kernals – Eign values and Egien functions – connection with differential equations – Solution of an integral equation – Initial value problems – Boundary value problem.

Chapter 1: 1.1 - 1.3 & 1.5 - 1.8 (Text Book - 2) **(18 Hours)**

Unit IV: Solution of Fredholm intergral equation

Second kind with separable kernel – Orthogonality and reality eigen function – Fredholm Integral equation with separable kernel – Solution of Fredholm Integral Equation by successive substitution – Successive approximation – Volterra integral equation – Solution by successive substitution.

Chapter 2: 2.1 - 2.3 and **Chapter 4:** 4.1 - 4.5 (Text Book - 2) **(18 Hours)**

Unit V: Hilbert – Schmidt Theory

Complex Hilbert space – Orthogonal system of function – Gram-Schmitorthognalization process – Hilbert-Schmidt theorems – Solutions of Fredholm of integral equation of first kind.

Chapter 3: 3.1 - 3.4 & 3.8 - 3.9 (Text Book - 2) **(18 Hours)**

Recommended Text Books:

- A.S. Gupta, Calculus of Variations with Application, Prentice Hall of India, New Delhi, 2005.

- Sudir K. Pundir and Rimple Pundir, Integral Equations and Boundary Value Problems, Pragati Prakasam, Meerut, 2005.

Reference Text Books:

- L. Elsgolts, Differential Equations and the Calculus of Variations Mir Publishers, Moscow, 1973.
- Ram P. Kanwal, Linear Integral Equations. Academic Press, New York, 1971.

ANALYTIC NUMBER THEORY (MDMA 43)
(CORE PAPER – 15**)**

Unit I: Divisibility theory in the integers

The Division Algorithm – The Greatest Common Divisor – The Euclidean Algorithm – The Diophantine equation $ax + by = c$, **Primes and their distribution:** The Fundamental theorem of Arithmetic.

Chapter 2: 2.1 – 2.4 and **Chapter 3:** 3.1 **(18 Hours)**

Unit II: The Theory of Convergences

Karl Friedrich Gauss - Basic Properties of Congruence – Specia Divisibility Tests – Linear congruences. **Fermat's Theorem:** Pierre de Fermat - Fermat's Factorization Method – The Little theorem and Wilson's theorem.

Chapter 4: 4.1 – 4.4 and **Chapter 5:** 5.1 – 5.4 **(18 Hours)**

Unit III: Number Theoretic Functions

The functions τ and σ - The Mobius inversion formula – The Greatest Integer Function. **Euler's generalization of Fermat's theorem:** Leonhard Euler – Euler's Phi-function – Euler's theorem

Chapter 6: 6.1 – 6.3 and **Chapter 7:** 7.1 – 7.3. **(18 Hours)**

Unit IV: Primitive Roots and Indices

The Order of an integer Modulo n – Primitive Roots for Primes – Composite Numbers having Primitive Roots – The Theory of Indices.

Chapter 8: 8.1 – 8.4 **(18 Hours)**

Unit V: The Quadratic Reciprocity law

Euler's Criterion – The Legendre Symbol and its properties – Quadratic Reciprocity – Quadratic Congruence with Composite Moduli.

Chapter 9: 9.1 - 9.4 **(18 Hours)**

Text book:

- David M. Burton, Elementary Number Theory, 6th edition, McGraw Hill, 2006.

Reference Books:

- Tom. M. Apostal, **"Introduction to Analytic Number Theory"**, Springer, New Delhi, 1993.
- Thomas Koshy, **"Elementary Number Theory"**, Elesvier, California, 2005.
- I. N. Robbins, **"Beginning Number Theory"**, 2nd Edition, Narosa Publishing, New Delhi, 2007.
- Gareth A. Jones and J. Mary Jones, **"Elementary Number Theory",** Springer Verlag, Indian Reprint, 2005.
- George Andrews, **"Theory of Numbers"**, Saunders, 1971.
- J.William, **"Fundamentals of Number Theory",** Leveque, Addison-Wesley Publishing Company, Phillipines, 1977.

GRAPH THEORY (MDMA 44)
(CORE PAPER - 16)

Unit I: Graphs and Sub-graphs

Graphs and simple graphs - Graph isomorphism - Incidence and adjacency matrices – Sub-graphs - Vertex degrees - Path and Connection cycles – Applications: The shortest path problem – Trees: Trees - Cut edges and bonds - Cut vertices - Cayley's formula.

Chapter 1 (Except 1.9) and **Chapter 2** (Except 2.5) **(18 Hours)**

Unit II: Connectivity

Connectivity – Blocks - Euler tours and Hamilton cycles: Euler tours – Hamilton cycles – Applications: The Chinese postman problem.

Chapter 3 (Except 3.3) and **Chapter 4** (Except 4.4) **(18 Hours)**

Unit III: Matchings

Matchings - Matching and coverings in bipartite graphs - Perfect matchings –. Edge colorings: Edge chromatic number - Vizing's theorem - Applications: The timetabling problem.

Chapter 5: (Except 5.5) and **Chapter 6** **(18 Hours)**

Unit IV: Independent sets and Cliques

Independent sets - Ramsey's theorem - Turan's theorem - Vertex colorings: Chromatic number - Brook's theorem – Hajo's conjecture - Chromatic polynomials - Girth and chromatic number.

Chapter 7: (Except 7.4 - 7.5) and **Chapter 8** (Except 8.6) **(18 Hours)**

Unit V: Planar graphs

Plane and planar graphs - Dual graphs - Euler's formula - Bridges - Kuratowski's Theorem (statement only) – The Five color theorem and The Four color conjecture - Non Hamiltonian planar graphs.

Chapter 9 (Except 9.8) **(18 Hours)**

Text Book:

- J.A.Bondy and U.S.R. Murthy, Graph Theory and Applications, Macmillan, London, 1976.

References:

- R.J. Wilson, Introduction to Graph Theory, Pearson Education, 4th Edition, 2004, Indian Print.
- J.Clark and D.A.Holton, A First look at Graph Theory, Allied Publishers, New Delhi, 1995.
- Douglas B.West, Introduction to Graph Theory, Pearson, 2000.
- Gary Chartrand, Introduction to Graph Theory, Tata McGraw-Hill Education, 2006.
- A.Gibbons, Algorithmic Graph Theory, Cambridge University Press, Cambridge, 1989.

ELECTIVE – IV
A. MATLAB & LaTeX (MDMA 45A)

UNIT I:

Introduction - Basics of MATLAB, Input – Output, File types – Platform dependence – General commands.

Chapter 1

UNIT II:

Interactive Computation: Matrices and Vectors – Matrix and Array operations – Creating and Using Inline functions – Using Built-in Functions and On-line Help – Saving and loading data – Plotting simple graphs.

Chapter 3

UNIT III:

Applications – Linear Algebra - Solving a linear system – Finding Eigen values and Eigen vectors – Matrix Factorizations.

Chapter 5: 5.1, 5.2

UNIT IV:

Applications – Data Analysis and Statistics – Numerical Integration – ordinary differential equations – Nonlinear Algebraic Equations.

Chapter 5: 5.3 to 5.6

UNIT V:

Chapters in Text book 2

Text Book:

- RUDRA PRATAP, Getting Started with MATLAB-A Quick Introduction for Scientists and Engineers, Oxford University Press, 2010.
- John Warbrick, Essential Latex++, 1994

Reference Books:

1. William John Palm, Introduction to Matlab 7 for Engineers, McGraw-Hill Professional, 2005.
2. Dolores M. Etter, David C. Kuncicky, Introduction to MATLAB 7, Prentice Hall, 2004.

B. DIFFERENTIAL GEOMETRY (MDMA 45B)

Unit - I:

Graphs and Level sets - Vector fields - Tangent space. **(18 Hours)**
Chapter: 1 - 3.

Unit – II:

Surfaces - Vector fields on surfaces. **(18 Hours)**
Chapter: 4 & 5.

Unit – III:

Gauss map – geodesics. **(18 Hours)**
Chapter: 6 & 7.

Unit – IV:

Parallel Transport - Weingarten map. **(18 Hours)**
Chapter: 8 & 9.

Unit V

Curvature of plane curves - arc length and Line integrals - Curvature of surfaces.
Chapter: 10 -12. **(18 Hours)**

Text Book:

- J.A.Thorpe, Elementary topics in Differential geometry, Undergraduate texts in Mathematics, Springer-Verlag,1979.

References :

- Struik, D.T. Lectures on Classical Differential Geometry, Addison - Wesley, Mass. 1950.
- Kobayashi S. and Nomizu. K. Foundations of Differential Geometry, Interscience Publishers, 1963.
- Wihelm Klingenberg: A course in Differential Geometry, Graduate Texts in Mathematics, Springer Verlag, 1978.
- T.J. Willmore, An Introduction to Differential Geometry, Oxford University Press,(17th Impression) New Delhi 2002. (Indian Print).

C. DIFFERENCE EQUATIONS (MDMA 45C)

UNIT I: LINEAR DIFFERENCE EQUATIONS OF HIGHER ORDER

Difference Calculus – General Theory – of Linear Difference Equations – Linear Homogeneous Equations with constant coefficients – Linear non-homogeneous Equations – Method of undetermined coefficients, the method of variation of constants – Limiting behavior of solutions.

Chapter 2: Sec 2.1 – 2.5 **(18 Hours)**

UNIT II: SYSTEM OF DIFFERENCE EQUATIONS

Autonomous system – The basic theory – The Jordan form – Linear periodic system.

Chapter 3: Sec 3.1 – 3.4 **(18 Hours)**

UNIT III: THE Z - TRANSFORM METHOD

Definition, Example and properties of Z-transform – The inverse Z-transform and solution of Difference Equations: Power series method, partial fraction method, the inverse integral method – Volterra Difference Equations of Convolution types – Volterra systems.

Chapter 5: Sec 5.1 – 5.5 (Except 5.4) **(18 Hours)**

UNIT IV: ASYMPTOTIC BEHAVIOR OF DIFFERENCE EQUATIONS

Tools and Approximations – Poincare's Theorem – Second order Difference Equations – Asymptotic diagonal systems – Higher order Difference Equations.

Chapter 8: Sec 8.2 – 8.5 **(18 Hours)**

UNIT V: OSCILLATION THEORY

Three-term Difference Equations – Non-linear Difference Equations – Self-Adjoint second order Equations.

Chapter 7: Sec 7.1 – 7.3 **(18 Hours)**

Recommended Text:

- Saber N.Elaydi, An Introduction to Difference Equations, Springer Verlag, New York, 1996.

Reference Books:

1. R.P. Agarwal., Difference Equations and Inequalities, Marcel Dekker, 1999.

2. S.Goldberg, Introduction to Difference Equations, Dover Publications, 1986.

3. V.Lakshmi Kantham and Trigiante, Theory of Difference Equations, Academic Press, New York, 1988.

4. Peterson, A Difference Equations, An Introduction with Applications, Academic Press, New York, 1991.

D. ALGEBRAIC GRAPH THEORY (MDMA 45D)

Unit I: Graphs and Groups

Graphs – Subgraphs – Automorhisms – Homomorphism - Circulant graphs - Johnson graphs - Line graph - Planar graphs. Groups: Permutation groups - Counting, Asymmetric graphs - Orbits on pairs.

Chapter 1 and **Chapter 2:** 2.1 - 2.4 **(18 Hours)**

Unit II: Transitive Graphs

Vertex Transitive Graphs - Edge Transitive Graphs - Edge connectivity - Vertex Connectivity.

Chapter 3: 3.1 - 3.4 **(18 Hours)**

Unit III: Transitive Graphs (Contd…)

Matchings - Hamiltonian path and Cycles - Cayley graphs – Directed Cayley graphs with No Hamiltonian Cycles.

Chapter 3: 3.5 - 3.8 **(18 Hours)**

Unit IV: Homomorphism

The Basics – Products - The Map Graph - Counting Homomorphism - Products and Colourings – Uniquely Colorable Graphs - Foldings and Covers.

Chapter 6: 6.1 & 6.3 - 6.8 **(18 Hours)**

Unit V: Matrix Theory

The Adjacency Matrix - The Incident Matrix – The Incident Matrix Oriented Graph – Symmetric Matrices – Eigen Vectors.

Chapter 8: 8.1 - 8.5 **(18 Hours)**

Recommended Text Book:

- Chris Godsil and Gordon Royle, Algebraic Graph Theory, Springer, 2001.

References:

1. Norman Biggs, Algebraic Graph Theory, Cambridge University Press, 1994.

2. Lowell W. Beineke, Robin J. Wilson, Peter J. Cameron, Topics in Algebraic Graph theory(Edited Volume), University of London