"கற்றகசடறக்கற்பவைகற்றபின்
நிற்கஅதற்குத்தக"(குறள். 391)

THIRUVALLUVAR UNIVERSITY

DEPARTMENT OF MATHEMATICS (300)

MASTER OF SCIENCE DEGREECOURSE
M. Sc. MATHEMATICS under CBCS

REGULATIONS& SYLLABUS

with effect from 2020−2021

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 practical's offered in the programme".

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

iii) **Open Elective courses :**
" The open Elective courses" related to the programme offered to the other University Departments".

iv) **Value Added Courses :**
" The Value Added courses" related to the programme concerned including basic knowledge software skills 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 weight age given to a course, usually in relation to the instructional hours assigned to it. For instance, a six-hours 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 isspread 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 PostgraduateProgrammesoffered 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 has 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 twosemestersin 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 has 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 evensemesters from December to April.

3. Course of Study:

The course of study for Master'sDegree Course in Mathematics shall consistof 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 **94** (ninety) Credits. The break-up of credits for the programme is as follows:

(a).	Core Courses	: 65credits
(b).	Core Elective Courses	: 12 credits
(c).	Value added course	: 2 credits
(d)	Open Elective course	: 4
(e).	Compulsory course	: 2 credits
(f).	Field Work	: 2 credits
(g).	Soft Skill	: 2 credits
(h).	Project	: 5 credits
	Total Credits	: **94 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 4thsemester, after completing his/her regular 2year 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 practicalin 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 practicalin 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 practicals of 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 practical of 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 Thiruvalluvar the University or has been exempted from in the manner prescribed and has passed the examinations as have been prescribed there for.

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 (300)
(with effect from 2020 - 2021)
The course of Study and the Scheme of Examinations:

Sl. No	Study Component	Course Title	Ins. Hrs. / Week	Credits	Title of the Paper	Maximum Marks		
						CIA	UNI. EXAM	TOTAL
IYEAR (I SEMESRTER)								
1	CORE	PAPER – 1	6	4	Algebra – I	25	75	100
2	CORE	PAPER – 2	6	4	Real Analysis – I	25	75	100
3	CORE	PAPER – 3	5	4	Ordinary Differential Equations	25	75	100
4	CORE	PAPER – 4	6	4	Mechanics	25	75	100
5	Value Added Course		2	2	Latex	25	75	100
6	CORE-ELECTIVE	PAPER – 1	5	3	**A)** Tensor analysis and Relativity theory **B)** Calculus of Variations and Integral Equations **C)** Difference Equation	25	75	100
Total			**30**	**21**	**Total**	**150**	**450**	**600**
I YEAR(II SEMESRTER)								
1	CORE	PAPER-5	5	4	Algebra – II	25	75	100
2	CORE	PAPER-6	5	4	Real Analysis – II	25	75	100
3	CORE	PAPER-7	5	4	Partial Differential Equations	25	75	100
4	CORE	PAPER-8	5	4	Applied Numerical Analysis	25	75	100
5	CORE-ELECTIVE	PAPER-2	5	3	**(A)**Mathematical Methods (B) Combinators (C)Financial Mathematics	25	75	100

6	OPEN ELECTIVE (Non Major)	PAPER - 1	3	2	(A) Mathematics for Competitive Examinations (B) Statistics (C) Bio-Mathematics	25	75	100
7	Compulsory Paper		2	2	Human Rights	25	75	100
Total			**30**	**23**	**Total**	**175**	**525**	**700**
II YEAR(III SEMESTER)								
1	CORE	PAPER-9	6	4	Topology	25	75	100
2	CORE	PAPER-10	6	4	Complex Analysis	25	75	100
3	CORE	PAPER-11	5	4	Graph Theory	25	75	100
4	CORE	PAPER-12	5	4	Applied Probability and Statistics	25	75	100
5	CORE-ELECTIVE	PAPER-3	5	3	A. Mathematical Modelling B. Applied Algebra C. Cryptography and Data Security	25	75	100
6	OPEN ELECTIVE	PAPER - 2	3	2	(A)Numerical Methods (B)Discrete Mathematics (C)Optimization Techniques	25	75	100
7	Soft skill Online course (MOOC Course)		---	2	As per University Regulations	---	---	100
8	Field work (USRR)		---	2	University Social Responsibility Report	---	---	100
Total			**30**	**25**	**Total**	**150**	**450**	**800**
II YEAR(IV SEMESTER)								
1	CORE	PAPER-13	6	5	Functional Analysis	25	75	100
2	CORE	PAPER- 14	6	4	Fluid Dynamics	25	75	100
3	CORE	PAPER-15	6	4	Number Theory	25	75	100
4	CORE	PAPER-16	6	4	Control Theory	25	75	100
5	CORE-ELECTIVE	PAPER - 4	6	3	A. Operations Research B. Fuzzy Mathematics C. Stochastic Differential	25	75	100

					Equation			
5	**CORE**	**Project Compulsory**	---	5	Project with viva voce	25(viva)	75 (project)	100
Total			**30**	**25**	**Total**	**125**	**375**	**600**

List of Core Elective Courses

S. No	Title
1	Tensor Analysis and Relativity Theory
2	Combinatorics
3	Difference Equation
4	Financial Mathematics
5	Mathematical Modelling
6	Applied Algebra
7	Applied Statistical Methods
8	Cryptography and Data Security
9	Fuzzy Mathematics
10	Mathematical Methods
11	Operations Research
12	Stochastic Differential Equations

List of Open Elective Courses

Sl.No	Title
1	Mathematics for Competitive Examinations
2	Statistics
3	Optimization Techniques
4	Numerical Methods
5	Bio-Mathematics
6	Discrete Mathematics

Distribution of Core, Core Elective, Open Elective and Compulsory Subjects

Subject	Papers	Credits	Total Credits	Marks	Total Marks
Core	16	4	65	100	1600
Core Elective	4	3	12	100	400
Value Added Course	1	2	02	100	100
Open Elective	2	2	04	100	200
Compulsory	1	2	02	100	100
Project	1	6	05	100	100
Soft Skill	1	2	02	100	100
Field Work	1	2	02	100	100
Total	**27**	**---**	**94**	**---**	**2700**

SEMESTER - I

ALGEBRA – I
(CORE PAPER – 1**)**

Objectives: To enable the students to acquire the basic knowledge in group theory and ring theory.

Course Outcome: At the end of the Course, the Students will able to	
CO1	Identify whether the given abstract structure is group or not.
CO2	Apply the concepts of homomorphism and isomorphism forcomparing the algebraic features of mathematical systems in groups and rings.
CO3	Define an automorphism of a group,Direct,semi direct Products and abelian groupssymmetric group, ring and some special classes of rings like commutative ring, fields.
CO4	Analyze Principal ideal domains,Polynomial rings – Definitions and basic properties.
CO5	Discussed about Euclidean domains, principal ideal domains and unique factorization

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 isomorphismtheorems - 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
(CORE PAPER – 2**)**

Objectives:: Develop the ability to reflect on problems that are quite significant in the field of real analysis. Develop the ability to reflect on problems that are quite significant in the field of real analysis. Ability to consider problems that could be solved by implementing concepts from different areas in mathematics. Ability to identify, formulate, and solve problems. Understanding of professional and ethical responsibilitiesS2-Communicate ideas effectively in graphical, oral, and written media

Course Outcome: At the end of the Course, the Students will able to	
CO1	students will be able to apply limiting properties to describe and prove continuity and differentiability conditions for real and complex functions.
CO2	Have a good understanding of **derivative** securities. Acquire knowledge of how forward contracts, futures contracts, swaps and options work, how they are used and how they are priced. Develop a reasoned argument in handling problemsabout functions, especially those that are of bounded variation
CO3	Be able to describe and explain the fundamental features of a range of key financial **derivative** instruments.
CO4	Learn the theory of Riemann-Stieltjes integrals, to be aquainted with the ideas of the total variation and to be able to deal with functions of bounded variation.
CO5	Knowledge of the implementation of theories in problem solving of Riemann-Stieltjesintegrals . create ability to understand the different math concepts and be able to implement them in our everyday problems.

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

(CORE PAPER – 3)

Objectives:

- The main purpose of the course is to introduce students to the theory and methods of ordinary differential equations.
- Students should be able to implement the methods taught in the course to work associated problems, including proving results of suitable accessibility.

Course Outcome: On successful completion of the course, the students will be able to	
CO1	Enhancing students to explore some of the basic theory of linear ODEs, gain ability to recognize certain basic types of higher-order linear ODEs for which exact solutions may be obtained, and to apply the corresponding methods of solution.
CO2	Able to solve non-homogeneous linear equations with constant coefficients using the methods of undetermined coefficients and variation of parameters and application problems modelled by linear differential equations
CO3	Recognize ODEs and system of ODEs concepts that are encountered in the real world, understand and be able to communicate the underlying mathematics involved in order to solve the problems using multiple approaches.
CO4	Students are introduced to modern concepts and methodologies in ordinary differential equations, with particular emphasis on the methods that can be used to solve very large-scale problems.
CO5	Introduction of Elementary Critical Points - System of Equations with constant coefficients and - Linear Equation with Constant Coefficients.

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)**

UnitIII: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
(CORE PAPER – 4**)**

Objectives:
- To Provide the classical mechanics approach to solve a mechanical problem.
- To study mechanical systems under generalized coordinate system, virtual work, energy and momentum.

Course Outcome: On successful completion of the course, the students will be able to	
CO1	Understand D'Alembert's Principle and simple application of Lagrangian formulation.
CO2	- Analyze the Derivation of Lagrange equation from Hamiltons's Principle and modified Hamilton's principle.
CO3	Dintinguishthe Concept of Hamilton equation of motion and Principle of least action
CO4	Obtain canonical equations using different combinations of generating functions and subsequently developing Hamilton Jacobi Method to solve equations of motion
CO5	Study the application of theory of canonical transformations to dynamical theory.

Unit - I: Introductory Concepts

The Mechanical system-Generalizedcoordinates - Holonomic and non- holonomic systems - constraints – Virtual work – D' Alembert'sprinciple – Energy and Momentum.

Chapter 1:1.1 – 1.5 **(18 Hours)**

Unit - II: Lagrange's Equations

Derivation of Lagrange'sequations – Examples – integralsof motion- cyclic or ignorablecoordinates.

Chapter 2:2.1 – 2.3 **(18 Hours)**

Unit - III: Hamilton'sEquations

Hamilton's principle - Hamilton's equations - other variational principle -Principle ofLeastaction.

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), NarosaPublishing 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 (3^{rd} Edition), McGraw Hill Book Co. New York, 1970.

Value Added Course

Latex

Pre-requisite: Basic knowledge of programming & Mathematics

Course Objectives:

Objectives	The main objectives of this course are to: 1. Introduce the Software knowledge in Latex 2. Learn Mathematics structures using Latex 3. Understanding the basic concepts and their properties are important for the development of the present and further courses.
Course Outcome: On the successful completion of the course, student will be able to:	
CO1	Remember to Download and install open source software Latex
CO2	Understanding and formatting Latex
CO3	Illustrate to learn to create Latex file
CO4	Apply and Analyze the Latex commands to large files
CO5	Able to learn mathematics derivations and structures using LATEX

Unit:1

Text formatting, TEX and its offspring

Unit:2

What's different in LATEX2ϵ , Distinguishing LATEX2 ϵ, Basic of a LATEX file

Unit:3

Commands and Environments-Command names and arguments, Declarations Lengths, special Characters.

Unit:4

Document layout and Organization-Document class, Page style, Parts of the Document

Unit:5

Table of Contents, Fine tuning text, Footnotes and marginal notes.

Books for study and References

1. H. Kopka and P.W. Daly , "A guide to LATEX" - third Edition, Addison –Wesley , London 1999.
2. **Stefan Kottwitz**"LaTeX Beginner's Guide: Create High-quality and Professional-looking Texts, Articles, and Books for Business and Science Using LaTeX" Packt Publishing, 2011.

Core ELECTIVE-Paper- I

A. TENSOR ANALYSIS AND RELATIVITY THEORY

Objectives:

- The main purpose of the course is to introduce students to understand the subject of differential geometry, where you talk about manifolds, one difficulty is that the geometry is described by coordinates, but the coordinates do not have meaning. They are allowed to undergo transformation. And in order to handle this kind of situation, an important tool is the so-called tensor analysis, which was new to mathematicians.
- Students should be able to implement the methods taught in the course to work associated problems, including proving results of suitable accessibility in different field..

Course Outcome: On successful completion of the course, the students will be able to	
CO1	Understand Tesor Algebra terminologies and different orders – Summation convention – Kronecker symbols – Transformation of coordinates in S_n. Invariants – Covariant and Contravariant vectors and arithemetics law related to tensor.
CO2	Discuss the Riemannian space – Christoffel symbols and their properties.
CO3	Tensor calculus fundamentals on Covariant differentiation of tensors – Riemann-Christoffel curvature tensor – Intrinsic differentiation are carried out.
CO4	Focus on special theory of relativityconcepts of Laurent's transformation equations, Einstein train – Time dilation – Longitudinal contraction – Invariant interval - Twin paradox.
CO5	Study the application of theory relativistic dynamics on Momentum-Energy four vector – Force – Conservation of energy – Principle of equivalence – Lagrangian and Hamiltonian formulations

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. Calculus of Variations and Integral Equations

Objectives	• The aim of the course is to introduce to the students the concept of calculus of variation and its applications. • Introduce various types of integral equations and how to solve these equations.
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Students know the concept and properties of variational problems with fixed and moving boundaries, functions of dependent and independent variables and also solve some applications problems in mechanics.
CO2	Able to solve differential equations and integral equation problems. Find the solution of eigen value, eigen functions.
CO3	Implementation of various methods to solve Fredholm Intergral equation.
CO4	Students gain acquire knowledge about Hilbert – Schmidt Theory
CO5	Deriving the complex Hilbert space – Orthogonal system of function and Solutions of Fredholm of Integral equation of first kind

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 RimplePundir, 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.

C. DIFFERENCE EQUATIONS

Objectives:

- Difference equations usually describe the evolution of certain phenomena over the course of time. The aim of studying this course is.
- To introduce the difference calculus.
- To study linear difference equations and to know how to solve them.
- To know the stability theory for homogeneous linear system of difference equations.
- To study the asymptotic behavior of solutions of homogeneous linear difference equations.

Course Outcome: After the successful completion of the course, students will be able	
CO1	To know the fundamentals of difference calculus, like, the difference operator, the computation of sums, the concept of generating function and the important Euler summation formula.
CO2	To solve linear difference equations using different methods, namely, annihilator method, z-transform method, etc.
CO3	To find the stability results for the linear system using eigen value criteria.
CO4	To find asymptotic analysis of sums, and asymptotic behavior of solutions to linear difference equations by the theorems of Poincare and Perron.
CO5	tTo solve the Three-term Difference Equations – Non-linear Difference Equations – Self-Adjoint second order Equations

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:

- SaberN.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.LakshmiKantham 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.

M.Sc., First Year - SEMESTER - II
ALGEBRA – II
(CORE PAPER – 5)

Objectives	✓ To facilitate the basic concepts of Vector Spaces andMatrix of a linear transformation. ✓ To enable students to learn Rational Canonical Form and Jordan Canonical Form in detail. ✓ To introduce the concept of Finite Fields
Course Outcome: At the end of the Course, the Students will able to	
CO1	Define the Matrix of a linear transformation and Dual vector spaces.
CO2	Comparison between Rational Canonical Form and Jordan Canonical Form, Field extensions and Algebraic Extensions.
CO3	Define Splitting fields, Algebraic closures and Cyclotomic polynomials.
CO4	Analyze the fundamental theorem of Galois theory.
CO5	Related definitions and fundamental theorem of Galois theory and Finite Fields.

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

(CORE PAPER – 6)

Objectives	✓ To introduce the concepts Double sequences, Double series and Multiplication of series ✓ To enable the students to know about Uniform convergence and Riemann-Stieltje's integration.
Course Outcome: At the end of the Course, the Students will able to	
CO1	Define Double sequences, Double series and Multiplication of series.
CO2	Distinguish Point-wise convergence of sequences of functionandUniform convergence of infinite series of functions.
CO3	Analyze Non-uniformly convergent sequences that can be integrated term by term,Sufficient conditions for uniform convergence of a series.
CO4	An application tocomplex-valued functions.
CO5	Apply Functions with non-zero Jacobian determinant.

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 - Cesarosummability - 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**", McGraw HillInc, 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
(CORE PAPER – 7)

OBJECTIVES	✓ Learn the elementary concepts and basic ideas involved in partial differential equations. ✓ Develop the mathematical skills to solve problems involving partial differential equations rather than general theory. ✓ Understand the partial differential equations as models of various physical processes such as mechanical vibrations, transport phenomena including diffusion, heat transfer and electrostatics.
Course Outcome: On successful completion of the course, the students will be able to	
CO1	Extract information from partial differential equations to interpret the reality.
CO2	Know the various types of methods and their limitations to solve the partial differential equations.
CO3	Identify the physical situations and real world problems to formulate mathematical models using partial differential equations.
CO4	Apply the acquired knowledge to select the most appropriate method to solve the particular partial differential equations.
CO5	To understand Formation and solution of one-dimensional & two dimensional wave equation - canonical reduction – IVP and BVP.

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,* 2ndEdn. 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 ValueProblems,* McGraw Hill, New York, 1968.
4. M.D.Raisinghania, *Advanced Differential Equations,*S.Chand& Company Ltd., New Delhi, 2001.

APPLIED NUMERICAL ANALYSIS
(CORE PAPER – 8)

Objectives:

- ✓ To know and apply different numerical techniques to solve algebraic and differential equations.
- ✓ To know methods of finding approximate values for definite integrals.

Course Outcome: At the end of the Course, the Students will able to	
CO1	Apply finite difference to evaluate polynomial using interpolation for equal andunequal intervals
CO2	Solve simultaneous linear equations by using Gauss elimination method, matrix inversion method, Gauss-Jordan Method, Gauss – Seidal method
CO3	Compute derivative of a function at the point in the given interval by using Newton's and Gauss forward and backward differences formulae.
CO4	Utilize General Quadrature formula, Trapezoidal rule, Simpson's rule, Weddle's Rule in integration and find the numerical solution of the first order ordinary differential equations
CO5	Analyzing the Difference Quotients - classification of PDE - Schmidt explicit formula – Crank-Nicolson method - Hyperbolic equations - Solution of two dimensional heat equations

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 $^{1}/_{3^{rd}}$ and $^{3}/_{8^{th}}$ 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.

Core Elective -Paper-II

A. MATHEMATICAL METHODS

Pre-requisite	• **The goal of the course is to understand the students the concept of mathematics applied in real life scenario.** • **Introduce Special functions, Integral transforms and problem solving in differential equations.**		

Course Objectives:

The main objectives of this course is to:

1. Generating the special functions of polynomials and series
2. Introduce fundamentals of infinite and finite Integral transforms and applying differential equation and integral equation.
3. Use in special functions, Integral transforms and differential equations as tools for problem solving

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

CO1	Understand to Generating the special functions such as Legendre functions and Bessel's functions, basic properties, solving in differential equations
CO2	Understand to solve the boundary value problems in such as a two and three dimension heat flow by using Fourier series
CO3	Acquire a basic knowledge in Fourier transform of properties, Derivatives and its application of Differential Equations
CO4	Acquire a basic knowledge in Laplace transform of properties, Derivatives and its application of Differential Equations
CO5	Apply the acquired knowledge in solving applied problems

Unit I: Legendre Differential Equation and Legendre Functions

Generating functions of Legendre polynomial – Rodrigue's Formula for Legendre Polynomials – Orthogonal Properties of Legendre's Polynomials – Recurrence Formulae for $P_n(x)$ – Expansion of Arbitary Functions in Series of Legendre polynomial.

Chapter:7.12 – 7.16 & 7.20 **(15 hours)**

Unit II: Bessel's Differentiation Equation; Bessel's Functions of first kind and Second Kind

Limiting values of $J_n(x)$ and $Y_n(x)$ –Differential Equations Reducible to Bessel's Equation-Bessel's Functions of third kind; Hankel Functions-Recurrence formulae for $J_n(x)$ –Generating Function for $J_n(x)$ –Jacobi Series- Bessel's Integrals-Orthonormality of Bessel's Functions.

Chapter:7.22 – 7.30 **(15 hours)**

Unit III : Fourier Equation of Heat Flow

Solution of Heat Flow Equation: Method of Separation of Variables-Linear Flow in Semi – infinite solid- Variable Linear Flow in an Infinite Bar-Two-Dimensional Heat Flow-Three Dimensional Heat Flow- Heat Flow in Circular Plate(Use of Cylindrical coordinates)

Chapter: 9.7-9.13 **(15 hours)**

Unit IV : Fourier Transform

Properties of Fourier Transform- Fourier Transform of a Derivative- Fourier sine and cosine Transforms of Derivatives- Fourier Transform of Functions of Two or Three Variables- Finite Fourier Transforms –Simple Applications of Fourier Transforms

Chapter: 10.2-10.8 **(15 hours)**

Unit V: Laplace Transforms

Properties of Laplace Transforms –Laplace Transform of the Derivative of a Function- Laplace Transform of Integral- Laplace Transform of Periodic functions- Laplace Transform of Some Special Functions- Inverse Laplace Transform – Properties of Inverse Laplace Transform - Evaluations of Inverse Laplace Transforms by Convolution Theorem- Method of Partial Fractions - Differential Equations - Applications of Laplace Transform

Chapter: 10.9-10.15, 10.17 & 10.19-10.22 **(15 hours)**

Recommended Text: SATYA PRAKASH, Mathematical Physics with Classical Mechanics, Sultan Chand & Sons, Educational Publishers, New Delhi, sixth revised 2012.

References :

1. Advanced Engineering & Sciences M.K.Venkataraman, The National Publishing Co.
2. F.B.Hildebrand. (1977) *Advanced Calculus for Applications.* Prentice Hall. New Jersey.
3. Engineering Mathematics Series, Veerarajan. T, Tata Mcgraw Hill Publication
4. Advanced Engineering Mathematics, Erwin Kreyszing, fifth edition, Wiley Eastern pubishers, 1985.

B. COMBINATORICS

OBJECTIVES	After completing this course, students will be Course Outcome: At the completion of the Course, the Students will able toGive an account of basic combinatorial concepts and principles; Use these to solve combinatorial problems
Course Outcome: On the successful completion of the course, student will be able to:	
CO1	Formulate important results and theorems covered by the course; Describe the main features of the proofs of important theorems; Present mathematical arguments to others.
CO2	Learn about recurrence relations. Learn the relationship between sequences and recurrence relations. Explore how to solve recurrence relations by iteration.
CO3	Learn about linear homogeneous recurrence relations and how to solve them Become familiar with linear non homogeneous recurrence relations.
CO4	Understand lattices as algebraic structures homomorphisms between lattices and Boolean Algebra polynomials, switching circuits.
CO5	Improve and implement stable and accurate numerical methods to solve linear systems of equations and find roots of linear and non-linear equations

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

C. FINANCIAL MATHEMATICS

Objectives: After completing the course students will understand the mathematical foundations of quantitative finance. Understand the standard and advanced quantitative methodologies and techniques of importance to a range of careers in investment banks and other financial institutions.Appreciation of emerging theory and techniques in the area of financial mathematic	
Course Outcome : At the end of the Course, the Students will able to	
CO1	Create and evaluate potential models for the price of shares.Construct, evaluate and analyze models for investments and securities.
CO2	Student can familiarize on computation of the present value and the accumulated value of a stream of equal or unequal payments using different kinds of interest rate.
CO3	Application of Capital investment and discount cash flow techniques are able to understand using compound interest function., Equation of value, Repayment by regular installments of interest and capital, discounted cash flow techniques.
CO4	Understand the investments and risk characteristics of the following types: Simple Compound interest problems. Design, build, investigate and evaluate forward contract using arbitrage-free pricing methods.
CO5	: Develop connections within branches of Financial Mathematics and between Probability and other disciplines like Reliability theory – Life time distributions – Hazard rate survival function.

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).

OPEN ELECTIVE (Non Major)-Paper-I
(A) Mathematics for Competitive Examinations

Prerequisite: Nil

Objective:

Outcome of the course:

Unit I: Problems on Ages – Percentage.

Unit II: Profit and Loss – Ratio and Proportion.

Unit III: Time and Work – Time Distance.

Unit IV: Simple Interest- Compound Interest

Unit V: Stocks and Shares – Bankers' Discount.

Text Book: Quantitative Aptitude by Dr.R.S. Aggarwal (Edition 2017), S. Chand Publishing, Section I: Chapter – 8, 11,12,13,17,18,22,23, 29 and 33.

(B). STATISTICS

OBJECTIVES	The aim of the course is to know various methods of collection of data. To focus on the descriptive statistics as well as understand univariate and bivariate data.
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Students understand the types of data. Collection, compilation, classification and tabulation of data. Also representation of data on diagrammatical and graphical are discussed.
CO2	Analysis of data among the measurements of central tendencies properties and simple problems are practiced.
CO3	Analysis of data among the measurements of dispersion or variations properties and simple problems are practiced.
CO4	To understand the knowledge and application of bivariate data using correlation analysis. Different kinds of correlation, it's properties and worked out real life problems.
CO5	In Regression analysis to understand the types of regression lines, equations, partial and multiple regression with practical examples.

UNIT I: Collection, classification and tabulation of data, graphical and diagrammatic representation – Bar diagrams.

UNIT II: Measures of central tendency – Mean, Median and Mode in series if individual observations, District series, Continuous series (inclusive).

UNIT III: Measures of dispersion – Range, Quartile deviation, Mean deviation about an average.

UNIT IV: Correlation – Different types of correlation – Positive, Negative, Simple, Partial, Multiple, Linear and non-Linear correlation.

UNIT V: Regression types and method of analysis, Regression line, Regression equations.

TEXT BOOK:

1. S.C.GUPTA AND V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi, 1994.

BOOKS OF REFERENCE:

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, I, World Press, Calcutta.

C. BIO-MATHEMATICS

OBJECTIVES	This course gives an introduction to mathematical modelling for biological systems. Introduce the Epidemicamodels, models for bio fluid and blood flood and diffusion reactions.
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Students understand the terminologies of single species non-age structured population models. Applying Logistic Modelswith Time- Age-scale population models- Continuous and -Time Discrete.
CO2	Understand the Epidemic models for deterministic models without removal and with removal and immigration. Also ,how to control of an epidemic are reviewed.
CO3	Emphasize on models for blood flow related to understand some basic concepts for fluid dynamics - about blood, cardiovascular system and blood flows. Application of steady non-Newtonian fluid flow in circular tubes, , blood flow through artery with mild stones are discussed.
CO4	Student can able to understand role mathematical models of flows for other Bio-fluids related to 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.
CO5	Role of diffusion and diffusion-Reaction Models for Artificial Kidney (Hemodialyser) – Oxygen Diffusion through Living Tissues are able to understand.

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: 8.1 – 8.7 and 8.9

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.

HUMAN RIGHTS

(COMPULSORY PAPER)

Objectives	of this paper is to know the human values and rights pertaining to contemporary economic situation. This will help the students in right perspectives.
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Explain the Human Values and rights pertaining to contemporary economic Situations.
CO2	Gain knowledge and awareness about Human rights and its Right Perspective.
CO3	Provides the capability to identify issues relating to Human Rights
CO4	Develops investigative and analytical skills relating to Human Rights
CO5	Understand the principles and institutions of International Human Rights.

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.

Field Study: Credits- 2 in 3rd semester: (doing between 2nd and 3rd semesters in summer holidays)

University Social Responsibility Report (USRR): Mathematics (300)

The aim of the Field Study is to help students connect with the society in the respective discipline. Following are the important features of the Field Study and the USRR:

1. Aim: The Field Study must aim at relating the subject of study with the society in so far as the application and the usefulness of the study are concerned

2. Topic selection: The topic for the Field Study must be chosen by the student in the second semester in the month of February; the process for the same shall begin on 1st February and shall end on the last working day of the month of February. Students are free to select the topic for the Field Study in consultation with the Experts and Faculty Members of their choice, both from within and outside the University

3. Period and duration: The Field Study shall be undertaken for a duration of 15 days in the summer vacation that falls immediately at the end of the second semester of the program and the same should be accounted for the Third Semester of the program

4. USRR: The USSR (University Social Responsibility Report) must be prepared by every student of the program written in 50 to 75 pages. The report shall be written based on the standard research methodology.

5. Review and evaluation schedule:

a. Reviewing the Field work: First week of July

b. Report Review: Second week of August

c. Report submission: First week of September

d. Report Evaluation: Third week of September

6. Faculty Composition: The following members may be nominated for confirming the topic and for evaluating the USRR:

a. Professor and Head of the concerned Department – Convener

b. One Faculty member with related field of specialization from the concerned Department-Member

c. One staff from the Institution of which the candidate proposed as a Filed work-Member

M.Sc., Second Year- SEMESTER III
TOPOLOGY
(CORE PAPER – 9**)**

Objectives:
To provide knowledge on point set topology, topological space, Quotient spaces, product spaces and metric spaces sequences, continuity of functions connectedness and compactness, homotopy and covering spaces.

Course Outcome: On successful completion of the course, the students will be able to	
CO1	Define and illustrate the concept of topological spaces and continuous functions.
CO2	Prove a selection of theorems concerning topological space, continuous functions, product topologies, and quotient topologies.
CO3	Define and illustrate the concept of product of topologies
CO4	and illustrate the concepts of the separation axioms.
CO5	Define connectedness and compactness, and prove a selection of related theorems, and describe different examples distinguishing general, geometric, and algebraic topology.

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 Limittheorem.

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 continuitytheorem–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 Topologyand 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.

COMPLEX ANALYSIS

(CORE PAPER – 10)

Objectives:

- To lay the foundation for this subject, to develop clear thinking and analyzing capacity for further study.
- Cauchy's Theorem guaranteeing that certain integrals along closed paths are zero. This striking result leads to useful techniques for evaluating real integrals based on the 'calculus of residues'.
- Important results are the Mean Value Theorem, leading to the representation of some functions as power series (the Taylor series), and the Fundamental Theorem of Calculus which establishes the relationship between differentiation and integration.

Course Outcome: On successful completion of the course, the students will be able to	
CO1	Analyze limits and continuity for complex functions as well as consequences of continuity.
CO2	Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra.
CO3	Evaluate integrals along a path in the complex plane and understand the statement of Cauchy's Theorem
CO4	Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.
CO5	Discuss Harmonic Functions, basic properties – and deriving the theorems Schwarz's aWeierstrass's, Taylor's series and Laurent series

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.

GRAPH THEORY

(CORE PAPER - 11)

Objectives: To enable the students to learn the fundamental concepts of Graphtheory

Course Outcome: At the end of the Course, the Students will able to	
CO1	Recognize the characteristics of graph
CO2	Convert the graph into matrix form and explain operations on graphs
CO3	Analyze special graphs like Eulerian graphs and Hamiltonian graphs with examples
CO4	Describe planar graphs and identify the chromatic number of the graph.
CO5	Discuss the different types of graphs and five color theorem and, four color conjecture - Non Hamiltonianplanar graphs.

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.

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

Objectives:
- ✓ To enable the students to acquire the knowledge of statistics
- ✓ To make the students understand various characteristics of discrete and continuous statistical distributions with mathematical techniques

Course Outcome : At the end of the Course, the Students will able to	
CO1	Describe the concepts of Random variables and Distribution Function with examples.
CO2	Evaluate Binomial, Poisson distributions, Regression and Correlationdistributions.
CO3	Analyze student's t-test, F-test and Chi-square test.
CO4	Analyze Randomized Block Design (RBD) and Latin Square Design (LSD).
CO5	Basic concept-Reliabilities of series.

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.

CORE ELECTIVE – Paper-III

A. MATHEMATICAL MODELLING

Objectives: ✓ To enable the students to acquire the knowledge of Mathematics in different field. ✓ To make the students understand various mathematical models using ODE , bio-fluid dynamics.	
Course Outcome : At the end of the Course, the Students will able to	
CO1	To understand mathematical modeling through system of ordinary differential equations in population dynamics, epidemics using first order.
CO2	Emphasize on models for blood flow related to understand some basic concepts for fluid dynamics - about blood, cardiovascular system and blood flows. Application of steady non-Newtonian fluid flow in circular tubes, , blood flow through artery with mild stones are discussed.
CO3	Student can able to understand role mathematical models of flows for other Bio-fluids related to 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.
CO4	Role of diffusion and diffusion-Reaction Models for Artificial Kidney (Hemodialyser) – Oxygen Diffusion through Living Tissues are able to understand.
CO5	Student can able to develop Mathematical Modelling through Calculus of Variations and Dynamic Programming using optimization principles and techniques –

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.

Recommended Text Book:

J.N. Kapoor, Mathematical Modelling, Wiley Eastern Limited, Reprint- 2000.

B. APPLIED ALGEBRA

Objectives	To facilitate the basic concepts of Boolean Algebras- Switches and Logic Gates To enable students to learn design of experiments, algebraic cryptography and coding theory.
Course Outcome: At the end of the Course, the Students will able to	
CO1	Introducing the Laws of Boolean Algebra- Polynomials and Functions. Gate Networks- Simplification of Circuits- Designing Circuits- Bridge Circuits.
CO2	Understand the area of design of experiments and formulatingand construction of matrix of a BIBD from Difference Sets- Quadratic Residues - Difference SetFamilies- Finite Fields- Nearrings- Planar Nearrings- Finite Integral Planar Nearrings. Canonical Form and Jordan Canonical Form, Field extensions and Algebraic Extensions.
CO3	Student able to know the field of algebraic cryptography for this to understand Algebraic Enciphering Algorithms and Classical Cryptosystems -Block Ciphers and Advanced Encryption Standard- Public-Key Cryptosystems.
CO4	Application of Coding Theory using Error-Correcting Codes- Linear Codes- Cyclic Codes- BCH Codes.
CO5	In the field of Symmetry Groups and Color Patterns to know the concepts on Permutation Groups- Symmetries- Colorings and Patterns- Action of a Group on a Setand Burnside Theorem.

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).

D.Joyner,R.Kreminski, J.Turisco -Applied Abstract Algebra(2003).

C. CRYPTOGRAPHY AND DATA SECURITY

Objectives: To provide conceptual understanding of network security issues, challenges and mechanisms. To develop basic skills of secure network architecture and explain the theory behind the security of different cryptographic algorithms.¬To describe common network vulnerabilities and attacks, defense mechanisms against network attacks, and cryptographic protection mechanisms.¬To explore the requirements of real-time communication security and issues related to the security of web services.	
Course Outcome : At the end of the Course, the Students will able to	
CO1	Learn to classify the symmetric encryption techniques
CO2	Learn Illustrate various Public key cryptographic techniques.
CO3	Evaluate the authentication and hash algorithms.
CO4	Learn to implement authentication applications
CO5	Summarize the intrusion detection and its solutions to overcome the attacks. Basic concepts of system level security

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.

OPEN ELECTIVE-Paper-II

A. NUMERICAL METHODS

Pre-requisite: Nil

OBJECTIVES	The main objectives of this course are to: 1. Solve complex mathematical problems using only simple arithmetic operations. The approach involves formulation of mathematical models of physical situations that can be solved with arithmetic operations. 2. Deal with various topics like finding roots of equations, solving systems of linear algebraic equations, interpolation and regression analysis, numerical integration & differentiation, solution of differential equation, boundary value problems, solution of matrix problems
Course Outcome: On the successful completion of the course, student will be able to:	
CO1	Apply numerical methods to obtain approximate solutions to mathematical problems
CO2	Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations
CO3	Work numerically on the ordinary differential equations using different methods through the theory of finite differences.
CO4	Familiar with numerical integration and differentiation, numerical solution of ordinary differential equations.
CO5	Improve and implement stable and accurate numerical methods to solve linear systems of equations and find roots of linear and non-linear equations

Unit:1 Solution Of Numerical Algebraic And Transcendental Equations

The Bisection Method – Method of Successive approximations -Regula –falsi Method.

Unit:2 Solution Of Numerical Algebraic And Transcendental Equations

Newton's Raphson Method - Convergence of Newton's Method and rate of Convergence.

Unit:3 Solution Of Simultaneous Linear Algebraic Equations

Gauss elimination method-Gauss Jordan method – Jacobi Iterative method - Gauss Seidal method - Comparison of Gauss elimination and Gauss Seidal Iteration Method.

Unit:4 Numerical Solution Of Ordinary Differential Equations

Introduction-Power series approximations-Pointwise methods-Solution by Taylor seriesTaylor series method for simultaneous first order differential equations.

Unit:5 Numerical Integration

Introduction-Trapezoidal rule-Simpson's one-third rule- Simpson's three-eighths rule.

Text Book(s)

1. P. Kandasamy, K.Thilagavathy, K.Gunavathi, Numerical Methods, S. Chand & Company Ltd., New Delhi, 2003.

2. S.C.Gupta and P.C.Raymond, Numerical Methods for Engineers, Tata McGraw Hill, New Delhi, 2000.

Reference Books:

1. M.K.Venkataraman, Numerical Methods in Science and Engineering, The National publishing company, Fifth Edition, 1999.

2. S.S.Sastry, Introductory methods of Numerical Analysis, Prentice Hall of India, New Delhi, 1998.

B. DISCRETE MATHEMATICS

Objectives: To develop logical thinking and its application to computer science (to emphasize the importance of proving statements correctly and de-emphasize the hand-waving approach towards correctness of an argument). The subject enhances one's ability to reason and ability to present a coherent and mathematically accurate argument. About 40% of the course time will be spent on logic and proofs and remaining 60% of the course time will be devoted to functions, relations, etc

Course Outcome: Upon completion of this course, the student will be able to:	
CO1	Construct mathematical arguments using logical connectives and quantifiers.
CO2	validate the correctness of an argument using statement and predicate calculus.
CO3	Understand how lattices and Boolean algebra are used as tools and mathematical models in the study of networks.
CO4	learn how to work with some of the discrete structures which include sets, relations, functions, graphs and recurrence relation..

Unit I: Mathematical Logic: Statement and notations, Connectives, Statement formulas and truth table, Conditional and bi-conditional statements, Tautology and contradiction, Equivalence of formulas, Tautological implications.

Unit II: Theory of Inference: Validity using truth table, Rules of inference, Consistency of premises and indirect method of proof, Predicates, Statement function, Variables, Quantifiers, Free and bound variables, Universe of discourse, Inference of the predicate calculus.

Unit III: Relation: Review of binary relations, equivalence relations, Compatibility relation, Composition of binary relations, Composition of binary relations and transitive closure, Partial ordering and partial ordered set.

Unit IV: Function: Review of functions and their enumeration, Pigeonhole principle. **Recurrence Relation:** Iteration, Sequence and discrete functions, Recurrence relations, Generating function.

Unit V: Lattice and Boolean Algebra: Lattice and algebraic system, Basic properties of algebraic systems, Special types of lattices, Distributed, Complemented lattices, Boolean algebra, Boolean expressions, Normal form of Boolean expressions, Boolean function and its applications to logic GATES.

Reference Books :

1. **J. P. Trembley** and **Manohar,** Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co. 1997.

2. Kenneth, H. Rosen, Discrete Mathematics and its Applications, WCB / McGraw Hill.

3. Liu, C.L., Elements of Discrete Mathematics, McGraw Hill , New York, (1978).

C. OPTIMIZATION TECHNIQUES

OBJECTIVES:

OBJECTIVES	To introduce the methods of optimization techniques. To understand the theory of optimization techniques for solving various types of optimization problems. To provide with basic skills and knowledge of optimization techniques and their applications. To make the students familiar in solving techniques, analysing the results and propose recommendations to the decision-making processes.
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Formulate a real-world problem as linear programming and queuing models
CO2	Assess the existence and uniqueness of solutions and derive necessary and sufficient optimality conditions for a given optimization problem.
CO3	Understand the mathematical tools that are needed to solve optimization problems

LEARNING OUTCOMES: At the end of the course, students will be able to ¬.¬ ¬.

Unit-1

Linear programming: Formulation – graphical solution. Simplex method.

Chapter 6

Unit – 3

Assignment problem: Mathematical Formulation. Comparison with Transportation Model.Hungarian Method. Unbalanced Assignment problems

Chapter 8

Unit – 2

Transportation problem: Mathematical Formulation. Basic Feasible solution. North WestCorner rule, Least Cost Method, Vogel's approximation. Optimal Solution.

Chapter 9

Unit – 3

Sequencing problem: n jobs on 2 machines – n jobs on 3 machines – two jobs on m machines – n jobs on m machines.

Chapter 10

Unit – 4

Game theory : Two-person Zero-sum game with saddle point – without saddle point –dominance – solving 2 x n or m x 2 game by graphical method.

Chapter 12 S

Unit – 5

Network: Project Network diagram – CPM and PERT computations.

Chapter 13

TEXT BOOK:

Operations Research, by R.K.Gupta , Krishna Prakashan India (p),Meerut Publications

Reference Books :

1. Gauss S.I. Linear programming , McGraw-Hill Book Company.

2 .Gupta P.K. and Hira D.S., Problems in Operations Research , S.Chand& Co.
4. Kanti Swaroop, Gupta P.K and Manmohan , Problems in Operations Research, Sultan Chand & Sons
5. Ravindran A., Phillips D.T. and Solberg J.J., Operations Research, John wiley& Sons.
6. Taha H.A. Operation Research, Macmillan pub. Company, New York.
7. Linear Programming, Transporation, Assignment Game by Dr.Paria, Books and

M.Sc. II Year (SEMESTER IV)

FUNCTIONAL ANALYSIS
(CORE PAPER – 13**)**

Objectives:

- This course introduces functional analysis and operator theoretic concepts. This area combines ideas from linear algebra and analysis in order to handle infinite-dimensional vector spaces and linear mappings thereof.
- This course provides an introduction to the basic concepts which are crucial in the modern study of partial differential equations, Fourier analysis, quantum mechanics, applied probability and many other fields.

Course Outcome: On successful completion of the course, the students will be able to	
CO1	Appreciate how ideas from different areas of mathematics combine to produce new tools that are more powerful than would otherwise be possible.
CO2	Understand how functional analysis underpins modern analysis.
CO3	Develop their mathematical intuition and problem-solving capabilities, especially in predicting the space in which the solution of a partial differential equation belongs to.
CO4	Learn advanced analysis in terms of Sobolev spaces, Besov spaces, Orlicz spaces and other distributional spaces.
CO5	Definition and examples of Banach Algebras – To understand the Regular and simple elements, radical and semi-simplicity

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.

FLUID DYNAMICS

(CORE PAPER - 14)

OBJECTIVES	The aim of the course is to discuss kinematics of fluids in motion, Equations of motion of a fluid, three dimensional flows, two dimensional flows and viscous flows.
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Students know what are Real fluids and ideal fluids, flows and solved problems regarding this.
CO2	Solved some problems and derivations about equation of motion of fluid and learn some naming theorems.
CO3	Students got some knowledge about some three dimensional and two dimensional flows.
CO4	To understand the geometrical knowledge of two dimensional flows – use of cylindrical polar coordinates and complex velocity potential for standard two dimensional flows – the Milne-Thomson circle theorem with examples.
CO5	Analyze the Stress components and relation between Cartesian components of stress, translation motion of a fluid element – the rate of strain quadric. Navier –Stokes equations of motion of a viscous fluid.

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 & 5.8 (18 Hours)

Unit V : Viscous Flows : Stress components in real fluids – relation between Cartesian components of stress – translation motion of a fluid element – the rate of strain quadric and principle stresses – Some further properties of the rate of strain quadric stress analysis in fluid motion – relation between stress and rate of strain – the co-efficient of viscosity and laminar flow– the Navier –Stokes equations of motion of a viscous fluid.
Chapter 8 : 8.1 –8.7 and 8.9 (18 Hours)

Text Book:

1. **F. Chorlton, Text book of Fluid Dynamics, CBS Publication, New Delhi, 1985.**
2. 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.

NUMBER THEORY

(CORE PAPER - 15)

OBJECTIVES	Find quotients and remainders from integer division. Apply Euclid's algorithm and backwards substitution, understand the definitions of congruences, residue classes and least residues. Add and subtract integers, modulo n, multiply integers and calculate powers, modulo n . Determine multiplicative inverses, modulo n and use to solve linear congruences.
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Learn to apply mathematical concepts and principles to perform numerical and symboliccomputations.use technology appropriately to investigate and solve mathematical and statisti-cal problems.
CO2	Learn write clear and precise proofs.iv. communicate effectively in both written and oral form. Understand the concept of a congruence and use various results related to con-gruences including the Chinese Remainder Theorem.
CO3	Demonstrate the ability to read and learn mathematics and/or statistics inde-pendently. Identify certain number theoretic functions and their properties
CO4	To dentify and apply various properties of and relating to the integers includingthe Well-Ordering Principle, primes, unique factorization, the division algorithm,and greatest common divisors.
CO5	Solve certain types of Diophantine equations. Identify how number theory is related to and used in cryptography.

UNIT I: Divisibility and Congruence:

Divisibility – Primes – Congruences – Solutions of Congruences – Congruences of Degree one. (Chapter 1: Sections 1.1 to 1.3 and Chapter 2: Sections: 2.1 to 2.3)

UNIT II: Congruence:

The function φ (n) – Congruences of higher degree – Prime Power moduli – Prime Modulus – Congruence's of degree two, Prime modulus – power Residues. (Chapter 2: Sections 2.4 to 2.9).

UNIT III: Quadratic Reciprocity:

Quadratic residues - Quadratic reciprocity - The Jacobi Symbol – Greatest Integer function. (Chapter 3: Sections 3.1 to 3.3 and Chapter 4: Section: 4).

UNIT IV: Some functions of Number Theory:

Arithmetic functions – The Mobius inverse formula – The multiplication of arithmetic functions. (Chapter 4: Sections 4.2 to 4.4).

UNIT V: Some Diaphantine Equations:

The equation ax+by = c – positive solutions – Other linear equations – The equation $X^2 + Y^2 = Z^2$ - The equation $X^4 + Y^4 = Z^4$ Sums of four and five squares – Waring's problem – Sum of fourth powers – Sum of two squares. (Chapter 5: Sections 5.1 to 5.10).

TEXT BOOK:

1.Ivan Niven and H.S Zuckerman, An Introduction to the Theory of Numbers, 3rd edition, Wiley Eastern Ltd., New Delhi, 1989.

BOOKS FOR REFERENCE:

1. D.M Burton, Elementary number Theory, Universal Book Stall, New Delhi 2001.
2. K. Ireland and M.Rosen, A Classical Introduction to Modern Number Theory, Springer Verlag, New York, 1972.
3. T.M Apostol, Introduction to Analytic Number Theory, Narosa Publication, House, Chennai, 1980.

CONTROL THEORY

(CORE PAPER - 16)

Objectives	1.The ability to understand the characteristics of various types of nonlinearities present in physical systems. 2.The ability to carry out the stability analysis of non-linear control systems. 3.To learn the methods for analyzing the behavior of nonlinear control systems and the designing of control systems
Course Outcome: At the completion of the Course, the Students will able to	
CO1	The ability to carry out the analysis and design of digital control systems.
CO2	The ability to design compensators for digital control system to achieve desired specifications. Ability to perform the stability analysis nonlinear systems by Lyapunov method develop design skills in optimal control problems
CO3	The ability to represent digital control systems using state space models. Ability to derive discrete-time mathematical models in both time domain (difference equations, state equations) and z-domain
CO4	The ability to analyze the effect sampling on stability, controllability and observability. Ability to predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems
CO5	The ability to design digital controllers for industrial applications. Ability to acquire knowledge of state space and state feedback in modern control systems, pole placement, design of state observers and output feedback controller.

Skill development: Understanding and learning how control theory underpins modern technologies and provides an insight in mathematical analysis.

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)

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.

CORE ELECTIVE – Paper-IV

A. OPERATIONS RESEARCH

Objectives: This Course aims to study the network problems, inventory models, linear programming problems, queuing models and replacement models in the real life situations.

Course Outcome: At the end of the Course, the Students will able to	
CO1	Discuss Basic ConceptsConvex sets, Linear Programming Problem.
CO2	Solve the Network problems by using CPM and PERT methods.
CO3	Identify EOQ of inventory models and when to replace an item in the replacement problems.
CO4	Compute the steady state probabilities for various queuing models.
CO5	Describethe Individual replacement and Group replacement.

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. HamdyA.Taha, Operations Research (6th 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 (8th Edition), Tata McGraw Hill Publishing Company, New Delhi, 2006.

B. FUZZY MATHEMATICS

Objectives	Familiarize the students with the fundamentals of fuzzy sets, operations on these sets and concept of membership function. Familiar with fuzzy relations and the properties of these relations .To know the concept of a fuzzy number and how it is defined. Become aware of the use of fuzzy inference systems in the design of intelligent systems
Course Outcome: At the completion of the Course, the Students will able to	
CO1	Understand the concepts of Fuzzy sets and its types – Characteristics – Significance of the paradigm shift.
CO2	Be able to distinguish between the crisp set and fuzzy set concepts through the learned differences between the crisp set characteristic function and the fuzzy set membership function.
CO3	To know Fuzzy intersection – t-norms, fuzzy unions – t-conorms. Combinations of operations – Aggregation operations.
CO4	Apply the concept of a fuzzy number and apply in real world problems
CO5	Student practice to construct various methods of fuzzy sets using sample data.

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.

C. STOCHASTIC DIFFERENTIAL EQUATIONS

OBJECTIVES	After completing this course, students will be able to interpret the concepts of random variables in terms of probability theory. Defines the concepts of probability space, random variable and probability distribution.
Course Outcome: On successful completion of the course, the students will be able to	
CO1	To know the fundamental concepts of Probability Spaces – Random variables and Stochastic Processes. Brownian motion – Construction of the Integral, Properties and its extensions.
CO2	The one dimensional and Multi-dimensional Formula are applied. Martingale Representation Theorem.
CO3	To find the Solution for an Existence and Uniqueness Result – Weak and Strong Solutions.
CO4	Introduction on one -Dimensional and Multidimensional Linear Filtering Problems are exercised.
CO5	Markov Property, Strong Markov Property – and Generator of Diffusion, Dynkin Formula are able to understand.

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:

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

CORE: PROJECT COMPULSORY

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