GURU NANAK COLLEGE (Autonomous)

VELACHERY ROAD, CHENNAI – 600042

(Re-Accredited 'A' Grade by NAAC)

MASTER OF SCIENCE IN MATHEMATICS

DEPARTMENT OF MATHEMATICS

(SEMESTER SYSTEM WITH CREDITS)

Regulations

&

Syllabus

APPENDIX – 11 (R & S)
UNIVERSITY OF MADRAS
GURU NANAK COLLEGE (AUTONOMOUS)

DEPARTMENT OF MATHEMATICS
PG BOARD OF STUDIES

Committee Members

1. Mr. K. Sivalingam- Chairman

2. Dr. T. V. Sudharsan- Subject Expert,
Academic Council Nominee
S.I.V.E.T College,
Gowriwakkam, Chennai – 73.

3. Dr. T. Jagathesan- Subject Expert,
Academic Council Nominee
R.K.M.Vivekananda College,
Mylapore, Chennai – 04.

4. Dr. K. Thangavelu - Vice Chancellor Nominee
Pachaiyappa's College,
E.V.R.Periyar High Road,
Chennai – 30.

5. Mr.V. Elanchezhiyan - Corporate Representative
Manager ,HSBC,M.G.R.Salai.
Perungudi,Chennai-96.

6. Mr. K. Sivaraman- Meritorious Alumni
Asst. Professor
L. N. Govt. Arts College,
TH Road, Thiruvallur,
Ponneri – 601204.

7. Mr. K. Sivalingam - Member, Guru Nanak College, Chennai

8. Mrs. N. Murugammal- Member, Guru Nanak College, Chennai

9. Mr. T. Harikrishnan - Member, Guru Nanak College, Chennai

10. Mr. K. Manikandan- Member, Guru Nanak College, Chennai

11. Mr. E. Thilakraj - Member, Guru Nanak College, Chennai

Minutes of the meeting

- The meeting (PG board of Studies) was held on Feb 03, 2017 at 2PM at the Dept. of Mathematics, Guru Nanak College.
- The detailed contents of all the PG Mathematics papers being offered were scrutinized and approved by the committee.
- The committee approve following modification in the syllabus

Paper	Deleted section	Added Section	Changed Paper
Core paper-I Algebra - I	Ch.- 3:Sec.-3.6 Ch.- 4:Sec.-4.5	Ch.- 2:Sec.-2.11, 2.12	
Core paper-I I Real Analysis-I	Ch.- 8:Sec.-8.17, 8.18,8.20 to 8.23 Ch.- 9:Sec.-9.13		
Core paper-I V Graph Theory	Ch.- 5:Sec.-5.1, 5.2 Ch.- 6 :Sec.-6.2		
Core paper-XII Mechanics	Ch.- 5:Sec.-5.3		
Core paper-XV Functional Analysis	Ch.- 4:Sec.-13,14 Ch.- 6:Sec.-23 Ch.- 7:Sec.-27,28	Ch.- 2:Sec.-6.6 to 6.8 Ch.- 2: Sec.-7.11 Ch.- 6:Sec.-22.4	
Elective Paper – V (Old) Tensor Analysis and Relativity			(New) Stochastic Processes

The revised patterns of the question paper starting from 2017-18 onwards as follows and is approved by the committee
Section A : Answer any 10 out of 12 questions 10x 3=30
Section B : Answer any 5 out of 7 questions 5x 6=30

Section C : Answer any 4 out of 6 questions 4x10=40

GURU NANAK COLLEGE(AUTONOMOUS),
Velachery Road, Chennai – 42
DEPARTMENT OF MATHEMATICS
PG BOARD OF STUDIES

RECEIPT

Received with thanks from the principal, Guru Nanak College, the honorarium (sitting fee) in connection with the meeting of the Board of Studies in Mathematics.

NAME		ADDRESS	SIGNATURE
1. Dr. T. V. Sudharsan	-	Subject Expert, Academic Council Nominee S.I.V.E.T College, Gowriwakkam, Chennai – 73.	
2. Dr. T. Jagathesan	-	Subject Expert, Academic Council Nominee R.K.M.Vivekananda College, Mylapore, Chennai – 04.	
3. Dr. K. Thangavelu	-	Vice Chancellor Nominee Pachaiyappa's College, E.V.R.Periyar High Road, Chennai – 30.	
4. Mr. V. Elanchezhiyan	-	Corporate Representative Manager , HSBC,M.G.R.Salai. Perungudi, Chennai-96.	
5. Mr. K. Sivaraman	-	Meritorious Alumni Asst. Professor L. N. Govt. Arts College, TH Road, Thiruvallur, Ponneri – 601204.	

NAME		ADDRESS	SIGNATURE
1. Mr. K. Sivalingam	-	Chairman	
2. Dr. T. V. Sudharsan	-	Subject Expert, Academic Council Nominee S.I.V.E.T College, Gowriwakkam, Chennai – 73.	
3. Dr. T. Jagathesan	-	Subject Expert, Academic Council Nominee R.K.M.Vivekananda College, Mylapore, Chennai – 04.	
4. Dr. K. Thangavelu	-	Vice Chancellor Nominee Pachaiyappa's College, E.V.R.Periyar High Road, Chennai – 30.	
5. Mr. V. Elanchezhiyan	-	Corporate Representative Manager , HSBC,M.G.R.Salai. Perungudi, Chennai-96.	
6. Mr. K. Sivaraman	-	Meritorious Alumni Asst. Professor L. N. Govt. Arts College, TH Road, Thiruvallur, Ponneri – 601204.	
7. Mrs. N. Murugammal	-	Member, Guru Nanak College, Chennai	
8. Mr. T. Harikrishnan	-	Member, Guru Nanak College, Chennai	
9. Mr. K. Manikandan	-	Member, Guru Nanak College, Chennai	
10. Mr. E. Thilakraj	-	Member, Guru Nanak College, Chennai	

DEPARTMENT OF MATHEMATICS
M.SC., SYLLABUS (W.E.F 2017-2018)
COURSE STRUCTURE

SEMESTER	SUBJECT TITLE		NO .OF. HRS PER WEEK	EXAM HRS	CREDITS	MARKS		TOTAL
						CIA	UE	
I	Core Paper-I	Algebra-I	5	3	4	50	50	100
	Core Paper-II	Real Analysis-I	6	3	4	50	50	100
	Core Paper-III	Ordinary Differential Equations	6	3	4	50	50	100
	Core Paper-IV	Graph Theory	6	3	4	50	50	100
	Elective paper -I	Fuzzy sets and Applications	6	3	4	50	50	100
	Soft skill Paper-I	Essential of language , communication Skills	1	3	2	40	60	100
II	Core Paper-V	Algebra-II	6	3	4	50	50	100
	Core Paper-VI	Real Analysis-II	6	3	4	50	50	100
	Core Paper-VII	Partial Differential Equations	6	3	4	50	50	100
	Core Paper-VIII	Probability Theory	6	3	4	50	50	100
	Elective paper -II	Programming in C++ and Numerical methods	5	3	4	50	50	100
	Soft Skill Paper-II	Computing Skills	1	3	2	40	60	100
		Summer Internship	-	-	2	-	-	-
III	Core Paper-IX	Complex Analysis -I	6	3	4	50	50	100
	Core Paper-X	Topology	6	3	4	50	50	100
	Core Paper-XI	Operation Research	6	3	4	50	50	100
	Core Paper-XII	Mechanics	6	3	4	50	50	100
	Elective paper -III	Number theory and Cryptography	5	3	4	50	50	100
	Soft Skill Paper-III	Managerial Skills	1	3	2	40	60	100
IV	Core Paper-XIII	Complex Analysis-II	6	3	4	50	50	100
	Core Paper-XIV	Differential Geometry	6	3	4	50	50	100
	Core Paper-XV	Functional Analysis	6	3	4	50	50	100
	Elective paper -IV	Mathematical Statistics	6	3	4	50	50	100
	Elective paper -V	Stochastic Processes	5	3	4	50	50	100
	Soft Skill paper-IV	Spoken and Presentation Skills	1	3	2	40	60	100
				TOTAL	90			

M.SC. DEGREE COURSE IN MATHEMATICS

Scheme of Examinations:

SEMESTER-I

PAPER NUMBER	COURSE COMPONENTS/TITLE	Credits	Exam Hours	Marks		Total
				CIA	UE	
Core Paper - I	Algebra-I	4	3	50	50	100
Core Paper - II	Real Analysis-I	4	3	50	50	100
Core Paper - III	Ordinary Differential Equations	4	3	50	50	100
Core Paper- IV	Graph Theory	4	3	50	50	100
Elective Paper - I	Fuzzy sets and Applications	4	3	50	50	100
Soft Skill Paper–I	Essential of language and Communication Skills	2	3	40	60	100

Elective - I
Any one of the following courses from Group-A shall be chosen as an Elective-I.

Group-A:

1. Formal Languages and Automata Theory
2. Discrete Mathematics
3. Mathematical Economics
4. Fuzzy sets and Applications.

SEMESTER-II

Core Paper - V	Algebra-II	4	3	50	50	100
Core Paper - VI	Real Analysis- II	4	3	50	50	100
Core Paper - VII	Partial Differential Equations	4	3	50	50	100
Core Paper- VIII	Probability Theory	4	3	50	50	100
Elective Paper - II	Programming in C++ and Numerical Methods	4	3	50	50	100
Soft Skill Paper -II	Computing Skills	2	3	40	60	100
	*Summer Internship	2				

Elective-II
Any one of the following courses from Group-B shall be chosen as an Elective-II.
Group-B:

5. Programming in C ++ and Numerical Methods
6. Mathematical Programming
7. Wavelets
8. Java Programming

* **Internship will be carried out during the summer vacation of the first year and marks should be sent to the University by the College and the same will be included in the Third Semester Marks Statement.**

SEMESTER-III

PAPER NUMBER	COURSE COMPONENTS/TITLE	Credits	Exam Hours	Marks		Total
				CIA	UE	
Core Paper - IX	Complex Analysis-I	4	3	50	50	100
Core Paper – X	Topology	4	3	50	50	100
Core Paper - X1	Operations Research	4	3	50	50	100
Core Paper - XII	Mechanics	4	3	50	50	100
Elective Paper -III	Number theory and Cryptography	4	3	50	50	100
Soft Skill Paper -III	Managerial Skills	2	3	40	60	100

Elective-III

Any one of the following courses from Group-C shall be chosen as Elective-III

Group-C

9. Algebraic Theory of Numbers
10. Number Theory and Cryptography
11. Tensor Analysis and Relativity
12. Data Structures and Algorithms

1. **Internship will be carried out during the summer vacation of the first year and marks should be sent to the University by the College and the same will be included in the Third Semester Marks Statement.**

SEMESTER-IV

Core Paper - XIII	Complex Analysis-II	4	3	50	50	100
Core Paper - XIV	Differential Geometry	4	3	50	50	100
Core Paper - XV	Functional Analysis	4	3	50	50	100
Elective Paper - IV	Mathematical Statistics	4	3	50	50	100
Elective Paper - V	Stochastic Processes	4	3	50	50	100
Soft Skill Paper -IV	Spoken and Presentation Skills	2	3	40	60	100

Elective-IV

Any one of the following papers from Group-D shall be chosen as Elective-IV.

Group-D:

13. Fluid Dynamics
14. Combinatorics
15. Mathematical Statistics
16. Algebraic Topology

Elective-V

Any one of the following papers from Group-E shall be chosen as Elective-V

Group – E

17. Stochastic Processes
18. Mathematical Physics
19. Financial Mathematics
20. Calculus of Variations and Integral Equations.

M.Sc. DEGREE COURSE IN MATHEMATICS
SYLLABUS

Semester -I
Core Paper I- Algebra – I

UNIT I-Another counting principle, Sylow theorems - Applications of Sylow theorems.
Recommended *Chapter 2: Section 2.11 and 2.12*
of I.N. Herstein *(18 hrs)*

UNIT II - Direct products : Internal direct product,External direct product, Finite abelian groups :Invariants of groups, Modules : Direct sum of modules, cyclic module, finitely generated module.

Recommended*Chapter 2: Sections 2.13 and 2.14,*
Chapter 4: Section 4.5of I.N. Herstein *(18 hrs)*

UNIT III - Linear Transformations - Canonical forms-Triangular form: Similar Transformation, Invariant under Linear Transformations – Nilpotent transformations.
Recommended*Chapter 6: Sections 6.4 , 6.5* of I.N. Herstein *(18 hrs)*

UNIT IV - Jordan form - rational canonical form: companion matrix of f(x).
Recommended*Chapter6 : Sections 6.6 and 6.7* of I.N. Herstein*(18 hrs)*

UNIT V - Trace and transpose - Hermitian, unitary, normal transformations, real quadratic form.
Recommended*Chapter 6 : Sections 6.8, 6.10 and 6.11 (Omit 6.9)*
of I.N. Herstein *(18 hrs)*

Recommended Text :

1. J. B. Fraleigh, A first course in Abstract Algebra, 5^{th} edition.
2. I. N. Herstein. Topics in Algebra (II Edition) Wiley, 2002.

Reference Books :

1. M. Artin, *Algebra*, Prentice Hall of India, 1991.
2. P. B. Bhattacharya, S. K. Jain, and S.R. Nagpaul, *Basic Abstract Algebra* (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. I. S. Luther and I. B. S. Passi, *Algebra*, Vol. I - Groups(1996); Vol. II Rings(1999), Narosa Publishing House , New Delhi
4. D. S. Dummit and R. M. Foote, *Abstract Algebra*, 2nd edition, Wiley, 2002.
5. N. Jacobson, *Basic Algebra*, Vol. I & II W. H. Freeman (1980); also published by Hindustan Publishing Company, New Delhi.

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Core Paper II-REAL ANALYSIS –I</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">An introductory real analysis course</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Functions of bounded variation - Introduction - Properties of monotonic functions - Functions of bounded variation - Total variation - Additive property of total variation - Total variation on [a, x] as a function of x - Functions of bounded variation expressed as the difference of two increasing functions - Continuous functions of bounded variation.
RecommendedChapter – 6 : Sections 6.1 to 6.8 ofTom M. Apostol

Infinite Series : Absolute and conditional convergence - Dirichlet's test and Abel's test.
RecommendedChapter 8 : Sections 8.8, 8.15

of Tom M. Apostol(18 hrs)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II : The 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 – Euler’s summation formula - Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper and lower integrals - Riemann's condition - Comparison theorems.

RecommendedChapter - 7 : Sections 7.1 to 7.14

ofTomM.Apostol (18 hrs)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III : The Riemann-Stieltjes Integral - Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of Riemann-Stieltjes integrals- Mean value theorems for Riemann - Stieltjes integrals - The integrals 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 integral-Riemann-Stieltjes integrals depending on a parameter-Differentiation under the integral sign-Lebesguecriteriaon for the existence of Riemann integrals.

RecommendedChapter - 7 : 7.15 to 7.24,7.26 of Tom M.Apostol (18 hrs)</td></tr>
</table>

	UNIT-IV :Infinite Series and infinite Products - Multiplication of series – Cesarosummability - Infinite products. Recommended**Chapter - 8 Sec, 8.20, 8.21 to 8.26** **Power series** - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem - Tauber's theorem ***Recommended Chapter 9 : Sections 9.14 9.15, 9.19, 9.20, 9.22, 9.23*** *of* ***Tom M.Apostol****(18 hrs)*
	UNIT-V: Sequences of Functions - Pointwise 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 - Uniform convergence and Riemann - Stieltjes integration – Non-uniform Convergence and Term-by-term Integration - Uniform convergence and differentiation - Sufficient condition for uniform convergence of a series. ***Recommended Chapter -9 Sec 9.1 to 9.6, 9.8,9.9, 9.10,9.11*** *of* ***Tom M.Apostol*** *(18 hrs)*
Recommended Text	Tom M. Apostol :*Mathematical Analysis*, 2nd Edition, Narosa,1989.
Reference Books	1. Bartle. R. G, *Real Analysis*, John Wiley and Sons Inc., 1976. 2. Rudin. W, *Principles of Mathematical Analysis*, 3rd Edition. McGraw Hill Company, New York, 1976. 3. Malik. S. C, and SavitaArora. *Mathematical Analysis*, Wiley Eastern Limited. New Delhi, 1991. 4. Sanjay Arora and BansiLal, *Introduction to Real Analysis*, SatyaPrakashan, New Delhi, 1991. 5. Gelbaum. B. R, and J. Olmsted, *Counter Examples in Analysis*, Holden day, San Francisco, 1964. 6. A. L. Gupta and N. R. Gupta, *Principles of Real Analysis*, Pearson Education, (Indian print) 2003.

Core Paper III - Ordinary Differential Equations

UNIT-I : **Linear equations with constant coefficients**

Second order homogeneous equations-Initial value problems-Linear dependence and independence-Wronskian and a formula for Wronskian-Non-homogeneous equation of order two.

Recommended*Chapter 2: Sections 1 to 6*ofE.A.Coddington

UNIT-II :**Linear equations with constant coefficients**

Homogeneous and non-homogeneous equation of order n –Initial value problems-Annihilator method to solve non-homogeneous equation.

Recommended*Chapter 2 : Sections 7 to 11* ofE.A.Coddington

UNIT-III :**Linear equation with variable coefficients**

Initial value problems -Existence and uniqueness theorems – Solutions to solve a non- homogeneous equation – Wronskian and linear dependence – Reduction of the order of a homogeneous equation – Homogeneous equation with analytic coefficients-The Legendre equation.

Recommended*Chapter : 3 Sections 1 to 8 (omit section 9)*ofE.A.Coddington

UNIT-IV :**Linear equation with regular singular points**

Second order equations with regular singular points –Exceptional cases – Bessel equation .

Recommended*Chapter 4 : Sections 3, 4 and 6 to 8 (omit sections 5 and 9)*ofE.A.Coddington

UNIT-V :**Existence and uniqueness of solutions to first order equations:**

Equation with variable separated – Exact equation – Method of successive approximations – the Lipschitz condition – Convergence of the successive approximations and the existence theorem.

Recommended*Chapter 5 : Sections 1 to 6 (omit Sections 7 to 9)*ofE.A.Coddington

Recommended Text

E.A.Coddington, *An introduction to ordinary differential equations* (3rd Printing) Prentice-Hall of India Ltd.,New Delhi, 1987.

Reference Books

2. Williams E. Boyce and Richard C. Di Prima, *Elementary differential equations andboundary value problems*,John Wiley and sons, New York, 1967.
3. George F Simmons, *Differential equations with applications and historical notes,* Tata McGraw Hill, New Delhi, 1974.
3. N.N. Lebedev, *Special functions and their applications*, Prentice Hall of India, New Delhi, 1965.
4. W.T.Reid. *Ordinary Differential Equations*, John Wiley and Sons, New York, 1971
5. M.D.Raisinghania,*Advanced Differential Equations*, S.Chand& Company Ltd. New Delhi 2001
6. B.Rai, D.P.Choudhury and H.I. Freedman, *A Course in Ordinary DifferentialEquations,* Narosa Publishing House, New Delhi, 2002.

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Core Paper IV - GRAPH THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core- IV</td><td>Year</td><td>I</td><td>Credits</td><td>4</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>I</td><td colspan="3"></td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">An elementary course in algebra</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I : Graphs, subgraphs and Trees : Graphs and simple graphs – Graph Isomorphism – The Incidence and Adjacency Matrices – Subgraphs – Vertex Degrees – Paths and Connection – Cycles.
Recommended Chapter 1 (Section 1.1 – 1.7)of J.A.Bondy and U.S.R. Murty
Omit Sections 1.8, 1.9</td></tr>
<tr><td colspan="6">UNIT-II : Cut Vertex and Connectivity : Trees – Cut Edges and Bonds- Cut Vertices– Connectivity - Blocks.
Recommended Chapter 2 (Section 2.1 - 2.3)
Chapter 3 (Section 3.1 – 3.2) of J.A.Bondy and U.S.R. Murty
Omit Sections 2.4 & 2.5
Omit Sections 3.3</td></tr>
<tr><td colspan="6">UNIT-III: Euler Tours, Hamilton Cycles and Edge Colourings: Euler Tours, Hamilton Cycles, Edge Chromatic Number
Recommended Chapter 4 (Section 4.1 – 4.2)
Chapter 6 (Section 6.1) of J.A.Bondy and U.S.R. Murty
Omit Sections 4.3 & 4.4
Omit Sections 6.2 & 6.3</td></tr>
<tr><td colspan="6">UNIT-IV: Independent sets and Cliques, Vertex Colourings : Independent sets – Ramsey's Theorem – Chromatic Number – Brooks' Theorem – Chromatic Polynomials.
Recommended Chapter 7 (Section 7.1 – 7.2)
Chapter 8 (Section 8.1 – 8.2, 8.4) omitted section 8.3of J.A.Bondy and U.S.R. Murty
Omit Sections 7.3, 7.4 & 7.5
Omit Sections 8.3, 8.5 & 8.6</td></tr>
<tr><td colspan="6">UNIT-V: Planar graphs : Plane and planar Graphs – Dual graphs – Euler's Formula – The Five- Colour Theorem and the Four-Colour Conjecture.
Recommended Chapter 9 (Section 9.1 – 9.3, 9.6)omitted sections 9.4 &9.5of J.A.Bondy and U.S.R. Murty
Omit Sections 9.4, 9.5, 9.7 & 9.8</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">J.A.Bondy and U.S.R. Murty ,Graph Theory and Applications , Macmillan, London, 1976.</td></tr>
</table>

Reference Books	1. J.Clark and D.A.Holton ,*A First look at Graph Theory,* Allied Publishers, New Delhi , 1995. 2. R. Gould. *Graph Theory*, Benjamin/Cummings, Menlo Park, 1989. 3. A.Gibbons, *Algorithmic Graph Theory*, Cambridge University Press, Cambridge, 1989. 4. R.J.Wilson and J.J.Watkins, *Graphs : An Introductory Approach*, John Wiley and Sons, New York, 1989. 5. R.J. Wilson, *Introduction to Graph Theory*, Pearson Education, 4th Edition, 2004, Indian Print. 6. S.A.Choudum, *A First Course in Graph Theory*, MacMillan India Ltd. 1987.

ELECTIVE PAPER- I

Title of the Course		A2. FUZZY SETS AND THEIR APPLICATIONS					
Paper Number		V					
Category	Elective-II	**Year**	**I**	**Credits**	**4**	**Course Code**	
		Semester	**I**				
Pre-requisite		**Knowledge of graphs, relations, composition**					
Course Outline		**UNIT-I :** Fundamental Notions: Review of the notion of membership, The concept of a fuzzy subset, Dominance relations, Simple operations on fuzzy subsets, Set of fuzzy subsets for E and M finite, Properties of the set of fuzzy subsets, Product and algebraic sum of two fuzzy subsets. Recommended**Chapter I: Sec. 1 to 8 of** A. Kaufman **(18 hrs)**					
		UNIT-II : Fuzzy Graphs: Fuzzy relations, composition of Fuzzy relations, Fuzzy subsets induced by a mapping, conditioned Fuzzy subsets, Properties of Fuzzy binary relations, Transitive closure of a Fuzzy binary relations, Paths in a finite Fuzzy graphs. Recommended**Chapter II: Sec. 10 to 18** **of** A. Kaufman **(18 hrs)**					
		UNIT-III : Fuzzy Relations: Fuzzy preorder relations, Similitude relations, Similitude subrelations in a fuzzy preorder, Antisymmetry, Fuzzy order relations, Antisymmetric relations without loops. Ordinal relations. Ordinal functions in a fuzzy order relation, Dissimilitude relations, Resemblance relations, Various properties of similitude and resemblance, Various properties of fuzzy perfect order relations. Recommended**Chapter II: Sec. 19 to 29 of** A. Kaufman **(18 hrs)**					

	UNIT-IV : Fuzzy Logic: Characteristic function of a fuzzy subset. Fuzzy variables, Polynomial forms, Analysis of a function of fuzzy variables. Method of Marinos, Logical structure of a function of fuzzy variables, Composition of intervals, Fuzzy propositions and their functional representations, The theory of fuzzy subsets and the theory of probability. Recommended**Chapter III: Sec.31 to 40 (omit Sec. 37, 38, 41) of** A. Kaufman **(18 hrs)**
	UNIT-V : The Laws of Fuzzy Composition: Review of the notion of a law of composition, Laws of fuzzy internal composition. Fuzzy groupoids, Principal properties of fuzzy groupoids, Fuzzy monoids, Fuzzy external composition, Operations on fuzzy numbers. Recommended**Chapter IV: Sec.43 to 49 of** A. Kaufman **(18 hrs)**
Recommended Text	A. Kaufman, *Introduction to the theory of Fuzzy subsets,*Vol.**I,** Academic Press, New York, 1975.
Reference Books	1. H. J. Zimmermann, *Fuzzy Set Theory and its Applications*, Allied Publishers, Chennai, 1996 2. George J. Klir and Bo Yuan, *Fuzzy sets and Fuzzy Logic-Theory and Applications*, Prentice Hall India, New Delhi, 2001.

Semester – II

Core Paper V - Algebra – II

UNIT I- Extension fields: Degree of extension fields, algebraic element, algebraic extension - Transcendence of e.
Recommended*Chapter 5: Section 5.1 and 5.2 of I. N. Herstein*
(18 hrs)

UNIT II -Roots of Polynomials: Simple roots, multiplicity roots, Splitting field- More about roots: derivative of f(x), simple extension
Recommended*Chapter 5: Sections 5.3 and 5.5of I. N. Herstein* **(18 hrs)**

UNIT III -Elements of Galois theory: Fixed field, Group of automorphisms relative to field, Splitting field of the polynomials, Normal extension of field, Galois group.
Recommended*Chapter 5 : Section 5.6 of I. N. Herstein* **(18 hrs)**

UNIT IV -Finite fields - Wedderburn's theorem on finite division rings
Recommended*Chapter 7: Sections 7.1 and 7.2 (Theorem 7.2.1 only) of I. N. Herstein* **(18 hrs)**

UNIT V -Solvability by radicals–Galois groups over the rational –A theorem On Frobenius.
Recommended*Chapter 5: Sections 5.7 and 5.8*
Chapter 7: Sections 7.3 of I. N. Herstein **(18 hrs)**

Recommended Text :

I. N. Herstein. Topics in Algebra (II Edition) Wiley 2002

Reference Books :

1. M. Artin, *Algebra*, Prentice Hall of India, 1991.
2. P. B. Bhattacharya, S. K. Jain, and S. R. Nagpaul, *Basic Abstract Algebra* (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. I. S. Luther and I. B. S. Passi, *Algebra*, Vol. I - Groups(1996); Vol. II Rings, (1999) Narosa Publishing House , New Delhi.
4. D. S. Dummit and R. M. Foote, *Abstract Algebra*, 2nd edition, Wiley, 2002.
5. N. Jacobson, *Basic Algebra*, Vol. I & II Hindustan Publishing Company, New Delhi.

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Core Paper VI - REAL ANALYSIS – II</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">VIII</td></tr>
<tr><td>Category</td><td>Core- VI</td><td>Year</td><td>I</td><td>Credits</td><td>4</td><td>Course Code</td><td></td></tr>
<tr><td></td><td></td><td>Semester</td><td>II</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Real Analysis-I</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Measure on the Real line - Lebesgue Outer Measure - Measurable sets - Regularity - Measurable Functions - Borel and Lebesgue Measurability
Recommended Chapter - 2 Sec 2.1 to 2.5 of de Barra</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II : Integration of Functions of a Real variable - Integration of Non-negative functions - The General Integral - Riemann and Lebesgue Integrals
Recommended Chapter - 3 Sec 3.1,3.2 and 3.4 of de Barra</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III : Fourier Series and Fourier Integrals - Introduction - Orthogonal system of functions - The theorem on best approximation - The Fourier series of a function relative to an orthonormal system - Properties of Fourier Coefficients - The Riesz-Fischer Thorem - The convergence and representation problems in for trigonometric series - The Riemann - Lebesgue Lemma - The Dirichlet Integrals - An integral representation for the partial sums of Fourier series - Riemann's localization theorem - Sufficient conditions for convergence of a Fourier series at a particular point - Cesarosummability of Fourier series- Consequences of Fejes's theorem - The Weierstrass approximation theorem
Recommended Chapter 11 : Sections 11.1 to 11.15 of Apostol</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV : Multivariable Differential Calculus - Introduction - The Directional derivative - Directional derivative and continuity - The total derivative - The total derivative expressed in terms of partial derivatives - The matrix of linear function - The Jacobian matrix - The chain rule - Matrix form of chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives - Taylor's theorem for functions of R^n to R^1
Recommended Chapter 12 : Section 12.1 to 12.14 of Apostol</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V : Implicit Functions and Extremum Problems : Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem-Extrema of real valued functions of severable variables-Extremum problems with side conditions.
Recommended Chapter 13 : Sections 13.1 to 13.7 of Apostol</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. G. de Barra, Measure Theory and Integration, New Age International, 2003 (for Units I and II)
2. Tom M.Apostol : Mathematical Analysis, 2nd Edition, Narosa 1989 (for Units III, IV and V)</td></tr>
</table>

Reference Books	1. Burkill,J.C. *The Lebesgue Integral*, Cambridge University Press, 1951. 2. Munroe,M.E. *Measure and Integration*. Addison-Wesley, Mass.1971. 3. Royden,H.L.*Real Analysis*, Macmillan Pub. Company, New York, 1988. 4. Rudin, W. *Principles of Mathematical Analysis*, McGraw Hill Company, New York,1979. 5. Malik,S.C. and SavitaArora. *Mathematical Analysis,* Wiley Eastern Limited. New Delhi, 1991.

Core Paper – VII - Partial Differential Equations

UNIT – I

Fundamental Concepts :

Introduction – Classification of Second Order PDE – Canonical Forms : Canonical Form for Hyperbolic Equation , Canonical Form for Parabolic Equation , Canonical Form for Elliptic Equation.

Recommended ***Section 1.1 to 1.3***of ***k.SankaraRao***

UNIT – II

Elliptic Differential Equations :

Occurrence of the Laplace and Poisson Equations: Derivation of Laplace Equation, Derivation of Poisson Equation. Boundary Value Problem (BVPs) – Some important Mathematical tools - Separation of Variables – Dirichlet Problem for a Rectangle - The Neumann Problem for a rectangle - Interior Dirichlet Problem for a Circle – Exterior Dirichlet Problem for a Circle – Interior Neumann Problem for a Circle- Solution of Laplace equation in cylindrical coordinates.

Recommended ***Section 2.1 to 2.3, 2.5 to 2.11***of ***k.SankaraRao***

UNIT – III

Parabolic Differential Equations:

Occurrence of The Diffusion Equation –Boundary Conditions – Elementary Solutions of the Diffusion Equation – Dirac Delta Function – Separation of Variables Method – Solution of diffusion equation in cylindrical coordinates.

Recommended ***Section 3.1 to 3.6***of ***k.SankaraRao***

UNIT –IV

Hyperbolic Differential Equations :

Occurrence of the Wave Equation – Derivation of One-dimensional Wave Equation – Solution of One-dimensional Wave Equation by Canonical Reduction – The Initial Value Problem ; D'Alembert's Solution – Vibrating String : Variables Separable Solution - Forced Vibrations: Solution of Non-homogeneous Equation – Boundary and Initial Value Problem for Two-dimensional Wave Equations: Method of Eigenfunction.

Recommended ***Section 4.1 to 4.7***of ***k.SankaraRao***

UNIT –V

Green's Function:

Introduction – Green's function for Laplace equation – the methods of Images – the eigenfunction method – Green's function for the wave equation: Helmholtz theorem – Green's function for the Diffusion equation.

Recommended ***Section 5.1.to 5.6.*** of***k.SankaraRao***

Recommended Text

"***Introduction to Partial Differential Equation"*** *by* ***k.SankaraRao ,*** *Third Edition,* PHI Learning Private Limited.

Reference Books

1. R.C Mc.Owen, Partial Differential Equations, 2nd edition Pearson Education. New Delhi,2005.

2. I.N.Sneddon, Elements of Partial Differential Equations, McGraw Hil, News Delhi, 1983.

3. R. Dennemeyer, Introduction to Partial Differential Equations and Boundry Value Problems, McGraw Hill, New York, 1968.

4.T.Amarnath, Partial Differential Equations, Narosa publishing House

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<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Core Paper VIII -PROBABILITY THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">X</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core- VIII</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level calculus and real analysis</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Random Events and Random Variables: Random events – Probability axioms – Combinatorial formulae – conditional probability – Bayes Theorem – Independent events – Random Variables – Distribution Function – Joint Distribution – Marginal Distribution – Conditional Distribution – Independent random variables – Functions of random variables.
RecommendedChapter 1: Sections 1.1 to 1.7
Chapter 2 : Sections 2.1 to 2.9 of M. Fisz</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II : Parameters of the Distribution : Expectation- Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors – Regression of the first and second types.
RecommendedChapter 3 : Sections 3.1 to 3.8 of M. Fisz</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III:Characteristic functions : Properties of characteristic functions – Characteristic functions and moments – semi0invariants – characteristic function of the sum of the independent random variables – Determination of distribution function by the Characteristic function – Characteristic function of multidimensional random vectors – Probability generating functions.
RecommendedChapter 4 : Sections 4.1 to 4.7 of M. Fisz</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV :Some Probability distributions: One point , two point , Binomial – Polya – Hypergeometric – Poisson (discrete) distributions – Uniform – normal gamma – Beta – Cauchy and Laplace (continuous) distributions.
RecommendedChapter 5 : Section 5.1 to 5.10 (Omit Section 5.11) ofM. Fisz</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V:Limit Theorems : Stochastic convergence – Bernaulli law of large numbers – Convergence of sequence of distribution functions – Levy-Cramer Theorems – de Moivre-Laplace Theorem – Poisson, Chebyshev, Khintchine Weak law of large numbers – Lindberg Theorem – LapunovTheroem – Borel-Cantelli Lemma - Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.
RecommendedChapter 6 : Sections 6.1 to 6.4, 6.6 to 6.9 , 6.11 and 6.12. (Omit Sections 6.5, 6.10,6.13 to 6.15) ofM. Fisz</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">M. Fisz, Probability Theory and Mathematical Statistics, John Wiley and Sons, New York, 1963.</td></tr>
</table>

Reference Books	1. R.B. Ash, *Real Analysis and Probability*, Academic Press, New York, 1972 2. K.L.Chung, *A course in Probability*, Academic Press, New York, 1974. 4. R.Durrett, *Probability : Theory and Examples*, (2nd Edition) Duxbury Press, New York, 1996. 5. V.K.Rohatgi*An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd., New Delhi, 1988(3rd Print). 6. S.I.Resnick, *A Probability Path*, Birhauser, Berlin,1999. 7. B.R.Bhat , *Modern Probability Theory* (3rd Edition), New Age International (P)Ltd, New Delhi, 1999

ELECTIVE PAPER - II

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">A4. PROGRAMMING IN C++ AND NUMERICAL METHODS
(Theory 75 marks(UE) + Computer Laboratory 25 marks(CIA))</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">V</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-II</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics of computer programming</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I :
Tokens, Expressions and Control Structures – Functions in C++
RecommendedChapters: 3 and 4 of (Balagurusamy)</td></tr>
<tr><td colspan="6">UNIT-II :
Classes and Objects – Constructors and Destructors – Operator Overloading and Type conversions
RecommendedChapters : 5, 6 and 7of(Balagurusamy)</td></tr>
<tr><td colspan="6">UNIT-III :
Inheritance – Pointers – Virtual Functions and Polymorphism
RecommendedChapters 8 and 9of(Balagurusamy)</td></tr>
<tr><td colspan="6">UNIT-IV :
The solution of Nonlinear Equations f(x)=0
RecommendedChapter2: Sec. 2.1 to 2.7of(John H.Mathews)
Interpolation and Polynomial Approximation
RecommendedChapter 4: 4.1 to 4.4 (omit Sec. 4.5 & 4.6)of(John H.Mathews)</td></tr>
<tr><td colspan="6">UNIT-V : Curve Fitting
RecommendedChapter 5: Sec. 5.1 to 5.3 (omit Sec. 5.4)of(John H.Mathews)
Solution of Differential Equations
RecommendedChapter 9: Sec. 9.1 to 9.6 (omit 9.7 to 9.9) of(John H.Mathews)</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw Hill, New Delhi, 1999.
John H.Mathews, Numerical Methods for Mathematics, Science and Engineering (2nd Edn.), Prentice Hall, New Delhi, 2000</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1.D. Ravichandran, Programming with C++, Tata McGraw Hill, New Delhi, 1996
2. Conte and de Boor, Numerical Analysis, McGraw Hill, New York, 1990</td></tr>
</table>

Semester III

Core Paper IX - Complex Analysis – I

UNIT I - **Cauchy's Integral Formula**: The Index of a point with respectto a closed curve - The Integral formula - Higher derivatives.
Local Properties of Analytical Functions : Removable Singularities-Taylors's Theorem-Zeros and poles-The local Mapping - The Maximum Principle .
Recommended*Chapter 4 : Section 2 : 2.1 to 2.3, Section 3 : 3.1 to 3.4*ofLars V. Ahlfors

UNIT II - **The general form of Cauchy's Theorem** : Chains and cycles-SimpleConnnectivity -Homology - The General statement of Cauchy's Theorem - Proof of Cauchy's theorem – Locally exact differentials-Multilply connected regions – Residue theorem - The argument principle.
Recommended*Chapter 4 : Section 4 : 4.1 to 4.7, Section 5: 5.1 and 5.2*ofLars V. Ahlfors

UNIT III - **Evaluation of Definite Integrals and Harmonic Functions:**
Evaluation of definite integrals - Definition of Harmonic functions and basic properties - Mean value property - Poisson formula.
Recommended*Chapter 4 : Section 5 : 5.3, Section 6 : 6.1 to 6.3*ofLars V. Ahlfors

UNIT IV - **Harmonic Functions and Power Series Expansions:**
Schwarz theorem - The reflection principle - Weierstrass theorem - Taylor Series - Laurent series .
Recommended*Chapter 4 : Sections 6.4 and 6.5*
Chapter 5 : Sections 1.1 to 1.3ofLars V. Ahlfors

UNIT V - **Partial Fractions and Entire Functions:** Partial fractions– Infinite products - Canonical products - Gamma Function - Jensen's formula
RecommendedChapter 5 : Sections 2.1 to 2.4, Section 3.1ofLars V. Ahlfors

Recommended Text :

Lars V. Ahlfors, Complex Analysis, (3rd edition) McGraw Hill Co., New York, 1979

Reference Books :

1. H.A. Priestly, *Introduction to Complex Analysis*, Clarendon Press,Oxford, 2003.
2. J.B.Conway, *Functions of one complex variable*, Springer International Edition, 2003
3. T.W Gamelin, *Complex Analysis,* Springer International Edition, 2004.
4. D.Sarason, *Notes on complex function Theory*, Hindustan Book Agency, 1998

Core Paper X – Topology

Unit I - Topological spaces, Basis for a topology, Product topology on X xY,Subspace topology, Closed sets and Limit points, Continuous functions.
Recommended*Chapter 2 - Sections 12, 13, 15, 16, 17, 18.*
*of*James R. Munkres **(18 hrs)**

Unit II - Connected spaces, Connected subspaces of the real line, Components and Localconnectedness, Compact spaces, Compact subspaces of the real line.
Recommended*Chapter 3 - Sections 23, 24, 25, 26, 27.*
*of*James R. Munkres **(18 hrs)**

Unit III - Countability axioms, Separation axioms, Normal spaces, UrysohnLemma, Urysohnmetrization theorem, Tietze extension theorem.
Recommended*Chapter 4 - Sections 30, 31, 32, 33, 34, 35.*
*of*James R. Munkres **(18 hrs)**

Unit IV - Product topology: J-tuple of elements, Cartesian product, box topology, product topology, Tychonoff theorem.
Recommended*Chapter 2 - Sections 19. of*James R. Munkres
Chapter 5 - Section 37. **(18 hrs)**

Unit V - Homotopy of paths: homotopic, null homotopic, path homotopic, product of two paths, Fundamental group: loop, fundamental group, simply connected set, homomorphism induced by a map.
Recommended*Chapter 9 - Sections 51, 52. of*James R. Munkres **(18 hrs)**

Recommended Text :

James R. Munkres *"Topology"* (Second edition) PHI, 2015.

Reference Books :

1. T. W. Gamelin and R.E. Greene, *Introduction to Topology*, The Saunders Series, 1983.
2. G. F. Simmons, *Introduction to Topology and Modern Analysis,* Mcgraw-Hill
3. J. Dugundji, *Topology*, Prentice Hall of India.
4. J. L. Kelly, *General Topology, Springer.*

S. Willard, *General Topology*, Addison-Wesley.

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">OPERATIONS RESEARCH</td></tr>
<tr><td colspan="2">Core Paper Number</td><td colspan="6">XI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core- XI</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG Level Operations Research</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Decision Theory : Steps in Decision theory Approach – Types of Decision-Making Environments – Decision Making Under Uncertainty – Decision Making under Risk – Posterior Probabilities and Bayesian Analysis – Decision Tree Analysis – Decision Making with Utilities.

Recommended Chapter 10 : Sec. 10.1 to 10.8 of J.K.Sharma</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II : Network Models : Scope of Network Applications – Network Definition – Minimal spanning true Algorithm – Shortest Route problem – Maximum flow model – Minimum cost capacitated flow problem - Network representation – Linear Programming formulation – Capacitated Network simplex Algorithm.

Recommended Chapter 6 : Sections 6.1 to 6.6of
H.A.Taha : Operations Research</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III : Deterministic Inventory Control Models: Meaning of Inventory Control – Functional Classification – Advantage of Carrying Inventory – Features of Inventory System – Inventory Model building - Deterministic Inventory Models with no shortage – Deterministic Inventory with Shortages

Probabilistic Inventory Control Models:
Single Period Probabilistic Models without Setup cost – Single Period Probabilities Model with Setup cost.
Recommended Chapter 13: Sec. 13.1 to 13.8
Chapter 14: Sec. 14.1 to 14.3ofJ.K.Sharma</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV :Queueing Theory : 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 – Erlangian Service times Distribution with k-Phases.

Recommended Chapter 15 : Sec. 15.1 to 15.8 ofJ.K.Sharma</td></tr>
</table>

	UNIT-V : Replacement and Maintenance Models: Failure Mechanism of items – Replacement of Items that deteriorate with Time – Replacement of items that fail completely – other Replacement Problems. Recommended **Chapter 16: Sec. 16.1 to 16.5 of**J.K.Sharma
Recommended Texts	1. For Unit 2 : H.A. Taha, *Operations Research*, 6th edition, Prentice Hall of India 2. For all other Units: J.K.Sharma, *Operations Research ,*MacMillan India, New Delhi, 2001.
Reference Books	1. F.S. Hiller and J.Lieberman -,*Introduction to Operations Research* (7th Edition), Tata McGraw Hill Publishing Company, New Delhui, 2001. 2. Beightler. C, D.Phillips, B. Wilde ,*Foundations of Optimization* (2nd Edition) Prentice Hall Pvt Ltd., New York, 1979 3. Bazaraa, M.S; J.J.Jarvis, H.D.Sharall ,*Linear Programming and Network flow,* John Wiley and sons, New York 1990. 4. Gross, D and C.M.Harris, *Fundamentals of Queueing Theory*, (3rd Edition), Wiley and Sons, New York, 1998.

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MECHANICS</td></tr>
<tr><td colspan="2">Core Paper Number</td><td colspan="6">XII</td></tr>
<tr><td>Category</td><td>Core</td><td>Year</td><td>II</td><td>Credits</td><td>4</td><td>Course Code</td><td></td></tr>
<tr><td></td><td></td><td>Semester</td><td>III</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Calculus and Differential equations.</td></tr>
<tr><td colspan="2" rowspan="3">Course Outline</td><td colspan="6">UNIT-I :Mechanical Systems : The Mechanical system- Equations of motion, Units. Generalised coordinates – Degrees of freedom, Generalised coordinates, configuration space. Constraints – Holonomic constraints, non holonomic constraints, Unilateral constraints. Virtual work – Virtual displacement, Virtual work, principle of virtual work, D’Alembert’s principle, Generalised force. Energy and Momentum - Potential energy, work and kinetic energy, conservation of energy, equilibrium and stability, kinetic energy of a system, angular momentum, Generalised momentum.
Recommended Chapter 1 : Sections 1.1 to 1.5 of D. Greenwood (18 hrs)</td></tr>
<tr><td colspan="6">UNIT-II :Lagrange's Equations: Derivation of Lagrange's equations- Kinetic energy, Lagrange’s Equations, Form of the equations of motion, non holonomic systems. Examples- Spherical pendulum, Double pendulum, Lagrange multipliers and constraint forces, Particle in whirling tube, particle with moving support, rheonomic constrained system. Integrals of motion- Ignorable coordinates,Example-the Kepler problem. Routhian function, conservative systems, Natural systems, Liouville’s system.
Recommended Chapter 2 : Sections 2.1 to 2.3 (Omit Section 2.4) of D. Greenwood (18 hrs)</td></tr>
<tr><td colspan="6">UNIT-III : Hamilton's Equations : Hamilton's Principle – Stationary values of a function, constrained stationary values, stationary value of a definite integral. Examples – geodesic path, case of n dependent variables, Hamilton’s principle, non holonomic systems, multiplier rule. Hamilton's Equation – Derivation of Hamilton’s equations, the form of the Hamiltonian function, Legendre transformation. Other variational principles – Modified Hamiltons principle, principle of least action.
Recommended Chapter 4 : Sections 4.1 to 4.3 (Omit section 4.4) of D. Greenwood (18 hrs)</td></tr>
</table>

	*UNIT – IV :**Hamilton-Jacobi Theory** : Hamilton Principle function – The canonical integral, Ptaffian differential forms. Hamilton-Jacobi Equation* **Recommended Chapter 5 : Sections 5.1 to 5.2of D. Greenwood (18 hrs)**
	*UNIT-V :**Canonical Transformation** : Differential forms and generating functions - canonical transformations, principal forms of generating functions, Further comments on the Hamilton- Jacobi method. Special Transformations– some special transformations, Homogeneous canonical transformations, point transformations, momentum transformations. Lagrange and Poisson brackets- Legendre brackets, Poisson brackets, The bilinear covariant.* **Recommended Chapter 6 : Sections 6.1, 6.2 and 6.3 (omit sections 6.4, 6.5 and 6.6) of D. Greenwood** **(18 hrs)**
Recommended Text	D. Greenwood, *Classical Dynamics*, Prentice Hall of India, New Delhi, 1985.
Reference Books	1. H. Goldstein, *Classical Mechanics,* (2nd Edition) Narosa Publishing House, New Delhi. 2. N.C.Rane and P.S.C.Joag, *Classical Mechanics*, Tata McGraw Hill, 1991. 3. J.L.Synge and B.A.Griffth, *Principles of Mechanics* (3rd Edition) McGraw Hill Book Co., New York, 1970.

ELECTIVE PAPER - III

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">NUMBER THEORY AND CRYPTOGRAPHY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-III</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Elementary number theory and calculus</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I :Elementary Number Theory:

Time Estimates for doing arithmetic – divisibility and Euclidean algorithm – Congruences – Application to factoring.

Recommended Chapter 1 of Neal Koblitz. (18 hrs)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II : Introduction to Classical Crypto systems

Some simple crypto systems – Enciphering matrices DES

Recommended Chapter 3 ofNeal Koblitz. (18 hrs)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III : Finite Fields, Quadratic Residues and Reciprocity

Recommended Chapter2 ofNeal Koblitz. (18 hrs)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV : Public Key Cryptography

The idea of public key Cryptography – RSA – Discrete log – Knapsack - Zero-knowledge protocols and oblivious transfer

Recommended Chapter 4 ofNeal Koblitz. (18 hrs)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V: Primality , Factoring, Elliptic curves and Elliptic curve crypto systems
Pseudoprimes – The Rho method – Fermat factorization and factor bases - The continued fraction method - The quadratic sieve method

Recommended Chapter 5, sections 1,2,3 & 5, Chapter 6, sections 1& 2 ofNeal Koblitz. (18 hrs)</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag, New York,1987</td></tr>
</table>

Reference Books	1.I. Niven and H.S.Zuckermann, *An Introduction to Theory of Numbers* (Edn. 3), Wiley Eastern Ltd., New Delhi,1976 2. David M.Burton, *Elementary Number Theory*, Brown Publishers, Iowa,1989 3. K.Ireland and M.Rosen, *A Classical Introduction to Modern Number Theory*, Springer Verlag, 1972 4. N.Koblitz, *Algebraic Aspects of Cryptography,* Springer 1998

Semester – IV

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">COMPLEX ANALYSIS- II</td></tr>
<tr><td colspan="2">Core Paper Number</td><td colspan="6">XIII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core- XIII</td><td>Year</td><td>II</td><td>Credits</td><td>4</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>IV</td><td colspan="3"></td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Complex Analysis-I and Real Analysis</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Riemann Zeta Function and Normal Famalies :
Product development – Extension of $\zeta(s)$ to the whole plane – The zeros of zeta function – Equicontinuity – Normality and compactness – Arzela's theorem – Families of analytic functions – The Classcial Definition
Recommended Chapter 5 : Sections 4.1 to 4.4, Sections 5.1 to 5.5 of Lars V. Ahlfors</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II :Riemann mapping Theorem : Statement and Proof – Boundary Behaviour – Use of the Reflection Principle.
Conformal mappings of polygons :Behaviour at an angle
Schwarz-Christoffel formula – Mapping of a rectangle.
Harmonic Functions : Functions with mean value property – Harnack's principle.
Recommended Chapter 6 : Sections 1.1 to 1.3 (Omit Section 1.4) Sections 2.1 to 2.3 (Omit section 2.4), Section 3.1 and 3.2 ofLars V. Ahlfors</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III : Elliptic functions : Simply periodic functions – Doubly periodic functions
Recommended Chapter 7 : Sections 1.1 to 1.3, Sections 2.1 to 2.4 ofLars V. Ahlfors</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV :Weierstrass Theory : The Weierstrass $\wp$-function – The functions $\zeta(s)$ and $\sigma(s)$ – The differential equation – The modular equation $\lambda(\tau)$ – The Conformal mapping by $\lambda(\tau)$.
Recommended Chapter 7 : Sections 3.1 to 3.5 ofLars V. Ahlfors</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V: Analytic Continuation :TheWeiesrtrass Theory – Germs and Sheaves – Sections and Riemann surfaces – Analytic continuation along Arcs – Homotopic curves – The Monodromy Theorem – Branch points.
Recommended Chapter 8 : Sections 1.1 to 1.7 ofLars V. Ahlfors</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">Lars V. Ahlfors, Complex Analysis, (3rd Edition) McGraw Hill Book Company, New York, 1979.</td></tr>
</table>

Reference Books	1.H.A. Priestly, *Introduction to Complex Analysis*, Clarendon Press,Oxford, 2003. 2.J.B.Conway, *Functions of one complex variable*, Springer International Edition, 2003 3.T.WGamelin, *Complex Analysis*, Springer International Edition, 2004. 4.D.Sarason, *Notes on Complex function Theory,* Hindustan Book Agency, 1998

Core Paper XIV
Differential Geometry

Unit I - Curves in the plane and in space :

Curves, parametrisation, arc length, level curves, curvature, plane and space curves.
Recommended *Chapters 1 and 2.of*A. Pressley

Unit II - Surfaces in space :

Surface patches, smooth surfaces, tangents, normals, orientability, examples of surfaces, lengths of curves on surfaces, the first fundamental form, isometries, surface area.
Recommended *Chapter 4 - 4.1, 4.2, 4.3, 4.4, 4.7 and Chapter 5 - 5.1, 5.2, 5.4of*A. Pressley

Unit III - Curvature of surfaces:

The second fundamental form, Curvature of curves on a surface, normal, principal, Gaussian and mean curvatures, Gauss map.
Recommended *Chapter 6 - 6.1, 6.2, 6.3 and Chapter 7 - 7.1, 7.5,7.6of*A. Pressley

Unit IV - Geodesics :

Geodesics, geodesic equations, geodesics as shortest paths, geodesic coordinates.
Recommended *Chapter 8 - 8.1, 8.2, 8.4, 8.5of*A. Pressley

Unit V - TheoremaEgregium of Gauss :

TheoremaEgregium, isometries of surfaces, Codazzi-Mainardi equations, compact surfaces of constant Gaussian curvature.
Recommended *Chapter 10of*A. Pressley

Recommended Text :

A. Pressley, *Elementary Differential Geometry*, Springer-Indian Edition, 2004.

Reference Books :

1. J.A. Thorpe, *Elementary Topics in Differential Geometry*, Springer-Indian edition.
2. E.D. Bloch, *A First Course in Geometric Topology and Differential Geometry*, Birkhauser, 1997.
3. M.P. doCarmo, *Differential Geometry of Curves and Surfaces*, Prentice-Hall, 1976.

Core Paper XV
Functional Analysis

Unit I: Normed Spaces – Riesz lemma –Continuity of Linear Maps.

Recommended Chapter-II: Sec 5.1 to 5.7, 6.1 to 6.5 of B.V. Limaye

Unit II: Bounded Linear Maps – Hahn Banach Theorems – Hahn-Banachseparation theorem – Hahn-Banachextension theorems,Unique Hahn BanachExtensions – Banach Spaces.

Recommended Chapter-II: Sec 6.6 to 6.8, 7.1 to 7.11, 8.1 to 8.4ofB.V. Limaye

Unit III: Uniform Boundedness Principle – Resonance theorem – Closed Graph Theorem– Open mapping Theorem – Bounded Inverse Theorem – Two-norm theorem.

Recommended Chapter-III: Sec 9.1 to 9.3, 10.1 to 10.7, 11.1 to 11.3ofB.V. Limaye

Unit IV: Spectrum of Bounded Operator – Weak and Weak* Convergence – Bolzano-Weierstrass Property –Reflexivity.

Recommended Chapter-III: Sec 12.1 to 12.5

Chapter-IV: Sec 15.1 to 15.4, 16.1 to 16.4ofB.V. Limaye

Unit V: Inner Product Spaces – Orthonormal Sets – Bessel's Inequality – Bounded Operators –Normal, Unitary and Self - Adjoint Operators.

Recommended Chapter-VI: Sec 21.1 to 21.3, 22.1 to 22.2, 22.4 to 22.7

Chapter-VII: Sec 25.2, 26.1 to 26.3ofB.V. Limaye

Recommended Text :

B.V. Limaye, Functional Analysis, New Age International, 1996.

Reference Books :

1. W.Rudin Functional Analysis, Tata McGraw-Hill Publishing Company, New Delhi , 1973
2. G.Bachman&L.Narici, Functional Analysis Academic Press, New York , 1966.
3. C. Goffman and G.Pedrick, First course in Functional Analysis, Prentice Hall of India, New Delhi, 1987
4. E. Kreyszig, Introductory Functional Analysis with Applications, John wiley& Sons, New York.,1978.
5. M.Thamban Nair, Functional Analysis. A First Course, Prentice Hall of India, New Delhi, 2002

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ELECTIVE PAPER IV

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MATHEMATICAL STATISTICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">XV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-IV</td><td>Year</td><td>II</td><td>Credits</td><td>4</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>IV</td><td colspan="3"></td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic Probability Theory</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Sample Moments and their Functions: Notion of a sample and a statistic – Distribution functions of X, S^2 and (X , S^2) - χ^2 distribution – Student t-distribution – Fisher's Z-distribution – Snedecor's F- distribution – Distribution of sample mean from non-normal populations
Recommended Chapter 9 : Sections 9.1 to 9.8of M. Fisz</td></tr>
<tr><td colspan="6">UNIT-II : Significance Test : Concept of a statistical test – Parametric tests for small samples and large samples - χ^2 test – Kolmogorov Theorem – Smirnov Theorem – Tests of Kolmogorov and Smirnov type – The Wald-Wolfovitz and Wilcoxon-Mann-Whitney tests – Independence Tests by contingency tables.
Recommended Chapter 10 : Sections 10.11
Chapter 11 : 12.1 to 12.7 ofM. Fisz</td></tr>
<tr><td colspan="6">UNIT-III : Estimation : Preliminary notion – Consistency estimation – Unbiased estimates – Sufficiency – Efficiency – Asymptotically most efficient estimates – methods of finding estimates – confidence Interval.
Recommended Chapter 13 : Sections 13.1 to 13.8 (Omit Section 13.9) ofM. Fisz</td></tr>
<tr><td colspan="6">UNIT-IV :Analysis of Variance : One way classification and two-way classification. Hypotheses Testing: Poser functions – OC function- Most Powerful test – Uniformly most powerful test – unbiased test.
Recommended Chapter 15 : Sections 15.1 and 15.2 (Omit Section 15.3)
Chapter 16 : Sections 16.1 to 16.5 (Omit Section 16.6 and 16.7) ofM. Fisz</td></tr>
<tr><td colspan="6">UNIT-V : Sequential Analysis : SPRT – Auxiliary Theorem – Wald's fundamental identity – OC function and SPRT – E(n) and Determination of A and B – Testing a hypothesis concerning p on 0-1 distribution and m in Normal distribution.
Recommended Chapter 17 : Sections 17.1 to 17.9
(Omit Section 17.10) of M. Fisz</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">M. Fisz ,Probability Theory and Mathematical Statistics, John Wiley and sons, New Your, 1963.</td></tr>
</table>

Reference Books	1. **E.J.Dudewicz and S.N.Mishra** ,*Modern Mathematical Statistics*, John Wiley and Sons, New York, 1988. 2. **V.K.Rohatgi***An Introduction to Probability Theory and Mathematical Statistics,* Wiley Eastern New Delhi, 1988(3rd Edn) 3. **G.G.Roussas**, *A First Course in Mathematical Statistics,* Addison Wesley Publishing Company, 1973 4.**B.L.Van der Waerden,***MathematicalStatistics,*G.Allen& Unwin Ltd., London, 1968.

ELECTIVE PAPER – V

STOCHASTIC PROCESSES

Unit I: Introduction - Specificationof stochastic processes – Stationary processes – Martingales– Markov chains: Definitions and examples –Higher transition probabilities.

Recommended **Chapter II:** Sections2.1 – 2.4,

Chapter III: Sections3.1 – 3.2**of J.MEDHI**

Unit II: Classifications of states and chains – Determination of higher transition probabilities.

Recommended **Chapter III:** Sections 3.4 – 3.5**ofJ.MEDHI**

Unit III: Poisson process - Poisson process and related distributions.

Recommended **Chapter IV:** Sections 4.1 – 4.2**ofJ.MEDHI**

Unit IV: Properties of generating functions of branching processes Probability of extinction

– Distribution of the total number of progeny – Conditional limit laws.

Recommended **Chapter IX :**Sections 9.1 - 9.5.1**ofJ.MEDHI**

Unit V: General concepts – M/M/1 steady state behaviour – Transient behaviour (Method of generating function) – Birth and death processes in queuing theory : Multi channel models.

Recommended **Chapter X :**Sections10.1 – 10.2, 10.3.2, 10.4.1, 10.4.2**ofJ.MEDHI**

Recommended Text

Stochastic Processesby**J.MEDHI,** 2nd Edition, New Age International (P) Ltd., 1984.

Reference

1. Cinlar.E., *Introduction to Stochastic Processes*, Englewood Cliffs,Prentice -Hall
2. Srinivasan S.K. and Mehata K.M., *Stochastic Processes*, 2nd Edition, Tata McGraw Hill, New Delhi, 1988.

Taylor H.N. and Karlin S., An Introduction to Stochastic Modeling, Academic Press.