ETHIRAJ COLLEGE FOR WOMEN

(AUTONOMOUS)

CHENNAI-600 008

COLLEGE WITH POTENTIAL FOR EXCELLENCE

DEPARTMENT OF MATHEMATICS

(Self Supporting)

M. Sc SYLLABUS

Choice Based Credit System

Outcome Based Education

(Offered from the academic year 2021-22)

BoS on 20/5/22

01/6/22

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CONTENTS

Department of Mathematics (Self Supporting)
Revised M. Sc Syllabus with effect from the academic year
2021-22 (CBCS – OBE Pattern)

PREAMBLE

As per the guidelines given by the University Grants Commission and the Tamil Nadu State Council for Higher Education, the M. Sc degree programme is designed in such a way that it finds extensive applications in both pure and applied Mathematics. It enhances problem formulation and problem solving skills of the students. Analytical skills and accuracy can be improved. An appreciation towards approaching of mathematical techniques and research aptitude can be realized. Due to varying capabilities of the students and to the present industrial needs, every effort has been made to present the subject in easy, clear, lucid and systematic manner, which will prepare the students to compete with industrial and corporate world, once they step out of the portal of this College. References at the end of each syllabus are given to cover more advanced extension of the topics presented.

REGULATIONS

1. ELIGIBILITY FOR ADMISSION:

Candidates for admission to the first year of the degree of M. Sc. Course should have Bachelor's degree in Mathematics from University of Madras or from some other University accepted by the syndicate as equivalent.

2. ELIGIBILITY FOR THE AWARD OF DEGREE:

The candidate shall be eligible for the award of degree only if she has undergone the prescribed course of study for a period of not less than two academic years, passed the examinations of all the four semesters prescribed, earning 91credits.

3. DURATION OF THE PROGRAMME: 2 YEARS

Each academic year is divided into two semester sessions. The first academic year shall comprise the first and second semesters. The second academic year comprises third and fourth semesters. Each semester will have a minimum of 90 working days and each day will have 5 working hours. Teaching is organized into a

modular pattern of credit courses. Credit is normally related to the number of teaching hours of a particular subject. It is also related to the number of tutorial and practical hours. **One Credit will be given to 1 Learning, 2 Tutorial and 2 Practical hours.**

COURSE OF STUDY:

The main subject of study for Master Degree shall consist of the following :

Courses	Number	Credits per Course	Total Credits
Core Courses			
Theory	15	4	60
Elective Courses			
Major	4	3	12
Non Major (Extra Disciplinary Elective)	2	3	6
Soft Skill	4	2	8
Internship	1	2	2
Project	1	3	3
		Total	**91**
Self Study paper (III Semester) (Optional) Extra Credits			**2 Credits per Paper**

4. PASSING MINIMUM:

A candidate shall be declared to have passed in each paper of the main subject of study wherever prescribed, if she secured NOT LESS THAN 50 % of the marks prescribed for the End Semester Examination and also 50% in the sum of End Semester Examinations and Continuous Assessment. There is no passing minimum for Continuous Assessment.

Eligibility Criteria to learn Self Study Paper: Students who have no arrears and who have obtained distinction in all the previous semesters alone are eligible.

5. CLASSIFICATION OF SUCCESSFUL CANDIDATES:

Successful Candidates passing the examination and securing the marks

1. 60% and above in aggregate shall be declared to have passed the Examination with first class.
2. 50% and above but below 60% in the aggregate shall be declared to have passed the examination in the second class.

Candidates who pass all the examinations prescribed for the course in the **FIRST ATTEMPT ALONE** are eligible for ranking.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

On obtaining a postgraduate degree the students will be able to:

PEO 1 – Display higher order thinking in the knowledge domain and demonstrate professional skills.

PEO 2 – Contribute to the advancement and application of relevant knowledge by self-directed learning.

PEO 3 – Extend and integrate knowledge and skills to design and develop novel products and explore innovative solutions to national and international goals of development.

PEO 4 – Exercise management skills and develop social interactions in a responsive, ethical and constructive way to meet global standards of excellence in all spheres of activity.

PEO 5 – Strive for social and economic equity based on the need for gender parity and ecological sustainability.

PROGRAMME OUTCOMES (POs)

(Common to all Science Streams)

Upon completion of the Programme, the students will be able:

PO 1 – To acquire advanced conceptual knowledge and comprehensive understanding of the fundamental principles in respective discipline.

PO 2 – To apply knowledge and critically evaluate the concepts and scientific developments to take up any challenge.

PO 3 – To visualize and work on laboratory multidisciplinary tasks related to current research in the fields of Mathematical, Physical and Life sciences.

PO 4 – To acquire research based knowledge and design methods to conduct investigations of complex problems in research/ Industrial field and achieve employability / self employment.

PO 5 – To communicate effectively ideas verbally in English, leading to entrepreneurship ventures such as consultancy and training.

PO 6 – To employ innovative and environment friendly methods, novel ideas to solve complex and challenging societal and environmental issues.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

Upon completion of the programme M. Sc Mathematics, the students will be able to:

PSO 1 – Apply knowledge of Mathematics in different field of science, business studies and technology.

PSO 2 – Acquire knowledge and understanding in advanced areas of Mathematics, from the courses offered.

PSO 3 – Provide students with advanced mathematical and computational skills that prepare them to pursue higher studies and conduct research.

PSO 4 – Train students to deal with the problems faced by software industry through knowledge of mathematics and scientific computational techniques.

PSO 5 – Provide students with knowledge and capability in formulating, analyzing mathematical models of real life applications, to develop abstract mathematical thinking and to crack the competitive examinations.

PROGRAMME PROFILE - DEPARTMENT OF MATHEMATICS

COURSE CODES AND CREDITS

TOTAL MINIMUM CREDITS: 91 TEACHING HOURS: 120

S.N	CORE/ ELECTIVE	TITLE OF THE PAPER	CODE	L	T	P	H	C	CA	SE	MM
	I SEMESTER										
1	**Core 1**	Algebra I	11SP21/1C/AL1	3	3	0	6	4	40	60	100
2	**Core 2**	Real Analysis I	11SP21/1C/RA1	3	3	0	6	4	40	60	100
3	**Core 3**	Ordinary Differential Equations	11SP21/1C/ODE	3	3	0	6	4	40	60	100
4	**Core 4**	Graph Theory	11SP21/1C/GTY	3	3	0	6	4	40	60	100
5	**Elective 1**	Mathematical Statistics I	11SP21/1E1/MS1	2	2	0	4	3	40	60	100
6	**Soft Skill 1**	Personality Enrichment for Women (Soft skills)	PG21/1S/PEW				2	2	-	50	50
			Total				30	21			
	II SEMESTER										
7	**Core 5**	Algebra II	11SP21/2C/AL2	3	2	0	5	4	40	60	100
8	**Core 6**	Real Analysis II	11SP21/2C/RA2	3	2	0	5	4	40	60	100
9	**Core 7**	Partial Differential Equations	11SP21/2C/PDE	3	2	0	5	4	40	60	100
10	**Core 8**	Mechanics and Tensor Analysis	11SP21/2C/MTA	3	2	0	5	4	40	60	100
11	**Elective 2**	Mathematical Statistics II	11SP21/2E2/MS2	2	2	0	4	3	40	60	100
12	**Extra Disciplinary Elective 1**	Mathematics for Competitive Examinations	11SP21/2E/MCE	2	2	0	4	3	40	60	100
13	**Soft Skill 2**	Language and Communication in English (Soft Skills)	PG21/2S/LCE PG21/2S/FRE PG21/2S/GER				2	2	-	50	50
14	**Internship**	During Summer Vacation					**Min. 21 days**	2			
			Total				30	26			

S.N	CORE/ ELECTIVE	TITLE OF THE PAPER	CODE	L	T	P	H	C	CA	SE	MM
	III SEMESTER										
15	**Core 9**	Complex Analysis I	11SP21/3C/CA1	**3**	**3**	**0**	**6**	**4**	**40**	**60**	**100**
16	**Core 10**	Topology	11SP21/3C/TOP	**3**	**2**	**0**	**5**	**4**	**40**	**60**	**100**
17	**Core 11**	Differential Geometry	11SP21/3C/DGY	**3**	**2**	**0**	**5**	**4**	**40**	**60**	**100**
18	**Elective 3**	**Option 1** Advanced Operations Research **Option 2** Fluid Dynamics	**Option 1** 11SP21/3E3/AOR **Option 2** 11SP21/3E3/FDY	**2**	**2**	**0**	**4**	**3**	**40**	**60**	**100**
19	**Elective 4**	**Option 1** Formal languages and Automata theory **Option 2** Measure Theory	**Option 1** 11SP21/3E4/FAT **Option 2** 11SP21/3E4/MTY	**2**	**2**	**0**	**4**	**3**	**40**	**60**	**100**
20	**Extra Disciplinary Elective 2**	Resource Management Techniques	11SP21/3E/RMT	**2**	**2**	**0**	**4**	**3**	**40**	**60**	**100**
20	**Soft Skill 3**	Analytical Skills for NET/SET	11SP21/3S/ASN	**2**	**0**	**0**	**2**	**2**	**-**	**50**	**50**
			Total				**30**	**23**			
	IV SEMESTER										
22	**Core 12**	Complex Analysis II	11SP21/4C/CA2	**3**	**3**	**0**	**6**	**4**	**40**	**60**	**100**
23	**Core 13**	Functional Analysis	11SP21/4C/FAN	**3**	**3**	**0**	**6**	**4**	**40**	**60**	**100**
24	**Core 14**	Numerical Python	11SP21/4C/NPY	**2**	**2**	**2**	**6**	**4**	**40**	**60**	**100**
25	**Core 15**	Calculus of Variations and Integral equations	11SP21/4C/CVI	**3**	**2**	**0**	**5**	**4**	**40**	**60**	**100**
26	**Project**	Project	11SP21/4C/PRO				**5**	**3**	**40**	**60**	**100**
27	**Soft Skill 4**	LATEX – A Document Preparation System	11SP21/4S/LAT	**0**	**0**	**2**	**2**	**2**		**50**	**50**
			Total				**30**	**21**			
			Grand Total					**91 Credits**			
	OPTIONAL (EXTRA CREDITS)										
I	**Self Study (Semester III)**	Special Functions	11SP21/3SS/SPF					**2**		**100**	**100**
		Introduction to Machine Learning	11SP21/3SS/MAL								

EVALUATION PATTERN FOR CONTINUOUS ASSESSMENT

INTERNAL VALUATION BY COURSE TEACHERS

Core / Elective / Project -Theory Papers

S. No	Component	Units to be Covered	Duration	Max. Marks	CA Marks
1.	Test I	I, II	2 hours	50 (to be converted)	**10**
2.	Test II	III, IV	2 hours	50 (to be converted)	**10**
3.	*Assignment/ Seminar/Field visit	-	-	10	**10**
4.	*Participatory Learning	-	-	10	**10**
				Total	**40**

* For Core 15: Numerical Python (11SP21/4C/NPY), instead of Assignment/ Seminar/Field visit and participatory Learning, Internal practical will be conducted for 20 marks.

PROJECT: No Continuous Assessment. Project report will be assessed and Viva-Voce will be conducted.

SOFT SKILL PAPERS: No Continuous Assessment.

C.A. QUESTION PAPER PATTERN:

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description / Problems – Three questions from every Unit	6 x 2	12
K_4, K_5	B	Analysis, Evaluation, Description/Problems – At least two question from every Unit	3(out of 5) x 6	18
K_4, K_5	C	Application/Analysis/Synthesis/ Evaluation – At least one question from every Unit	2(out of 3) x10	20
			Total	**50**

RUBRICS FOR CONTINUOUS ASSESSMENT

Assignment	Content/originality/Presentation/Schematic Representation and Diagram/Bibliography
Seminar	Organization /Subject Knowledge VisualAids/Confidence level/presentation-Communication and Language
Problem Solving	Understanding Concepts/Formula and Variable Identification/Logical Sequence/Answer
Participation	Answering Questions/Clearing Doubts/Participating in Group Discussions/Regular Attendance
Group Discussion	Preparation/Situation Analysis/Relationship Management/Information Exchange/Delivery Skills
Flipped/Blended Learning	Preparation/Information Exchange/Group interaction/Clearing doubts

END SEMESTER EVALUATION PATTERN

Semester	Papers	Valuation	Examiner	Max. marks	Passing Min.
All Semesters	Theory	Double Evaluation	Internal & External Examiner	100 (to be converted to 60)	50
All Semesters	Soft Skills	Single Evaluation	Internal examiner	50	25
End of II Semester	Internship	-	-	Two Credits	-
IV	Project	Double Evaluation	Internal & External Examiner	100	50
III	Self Study paper (Extra Credits)	Single Evaluation	Internal examiner	100	50

SEMESTER I COURSE PROFILE - M. Sc Mathematics

Course Title & Course Code	Credits	Hours/week	Total Hours	L	T	P	C.A	S.E	Total	Page No.
Algebra- I 11SP21/1C/AL1	4	6	90	3	3	0	40	60	100	**10**
Real Analysis - I 11SP21/1C/RA1	4	6	90	3	3	0	40	60	100	**13**
Ordinary Differential Equations 11SP21/1C/ODE	4	6	90	3	3	0	40	60	100	**16**
Graph Theory 11SP21/1C/GTY	4	6	90	3	3	0	40	60	100	**19**
Mathematical Statistics - I 11SP21/1E1/MS1	3	4	60	2	2	0	40	60	100	**22**
Personality Enrichment for Women (Soft Skills) PG21/1S/PEW	2	2	30				-	-	50	

SEMESTER – I

ALGEBRA – I

Core - 1 **Course Code: 11SP21/1C/AL1**
Teaching Hours: 90 **Credits: 4 L T P: 3 3 0**

Course Objectives:

To enable the students to

1. Understand the concepts of Advanced algebra
2. Get knowledge on application of Finite Abelian groups
3. Study linear Transformations
4. Understand the concepts of Nilpotent transformation.
5. Introduce different forms of matrices and quadratic forms.

COURSE OUTLINE:

UNIT I: **Group Theory**

Another Counting Principle - Sylow's Theorem (For Theorem 2.12.1 First proof only).

Chapter 2: Sections 2.11 and 2.12
(Omit Lemma 2.12.1, 2.12.2 & 2.12.5) **(20 hrs)**

UNIT II: Group Theory(contd.), Modules

Direct Products - Finite Abelian Groups - Modules.

Chapter 2: Sections 2.13 and 2.14 (Theorem 2.14.1 only)
Chapter 4: Section 4.5 **(20 hrs)**

UNIT III: Linear Transformations

Canonical Forms: Triangular Form.

Chapter 6: Section 6.4 **(15 hrs)**

UNIT IV: Linear Transformations (contd.)

Canonical Forms: Nilpotent Transformations – A Decomposition of V: Jordan Form.

Chapter 6: Sections 6.5 and 6.6 **(15hrs)**

UNIT V : Linear Transformations (contd.)

Hermitian, Unitary and Normal Transformations- Real Quadratic Forms.

Chapter 6: Sections 6.10 and 6.11 **(20 hrs)**

RECOMMENDED TEXT:

I. N. Herstein, Topics in Algebra (II Edition), John Wiley & Sons, 2019.

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. Lutherand I.B.S Passi, Algebra, Vol – I Groups (1996): Vol II Rings, Narosa Publishing House, New Delhi,1999.
4. N. Jacobson, Basic Algebra, Vol. I &II, Hindustan Publishing Company, NewDelhi,1974.
5. John B. Fraleigh, A First Course in Abstract Algebra, Pearson Education Publishing Company, 7th Edition, 2002.

Journals:

Journal of Algebra and its applications
Journal of Applied Mathematics
The Mathematics Intelligencer
Mathematics Newsletter.

Websites and e- learning sources

http://math-forum.org
http://www.opensource.org
https://brilliant.org/wiki/sylow-theorems/
https://groupprops.subwiki.org/wiki/Finite_abelian_group
https://planetmath.org/nilpotent transformation

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

CO No.	CO statement
CO 1	Acquire knowledge about counting principle, analyze three parts of Sylow's theorem and illustrates a different aspect of group theory.
CO 2	Explain on the application of Finite Abelian groups
CO 3	Discuss the concepts of Canonical Forms and Triangular Form.
CO 4	Explain the applications of Nilpotent Transformations.
CO 5	Compute the problems under Hermitian, Unitary and Normal Transformations.

MAPPING – Course Outcomes with Programme Specific Outcomes

CO / PSO	PSO 1	PSO 2	PSO3	PS04	PSO5
CO 1	2	2	2	1	3
CO 2	3	2	2	1	2
CO 3	3	2	3	1	2
CO 4	3	2	2	1	2
CO 5	2	2	2	2	3
Average	**2.6**	**2.0**	**2.2**	**1.2**	**2.4**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1

No correlation-0

Teaching Methodology

Lecture (chalk and talk, LCD projector), Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar.

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

REAL ANALYSIS - I

Core - 2 **Course Code: 11SP21/1C/RA1**

Teaching hours: 90 **Credits: 4 LTP: 3 3 0**

Course Objectives:

To enable the students to gain knowledge in

1. Functions of bounded variation
2. Riemann - Stieltjes Integration
3. Uniform Convergence
4. The interplay between various limiting operations.
5. Pointwise convergence and Uniform Convergence

COURSE OUTLINE:

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 increasing functions- Continuous functions of bounded variation.

Chapter 6: Sections 6.1 to 6.8 **(18 hrs)**

UNIT II: **The Riemann – Stieltjes Integral**

Introduction-Notation-The definition of the Riemann-Stieltjes integral-Linear Properties – Integration by parts - Change of variable in Riemann- Stieltjes integral – Reduction to Riemann integral- Euler Summation formula – Monotonically increasing integrators- Upper and Lower integrals- Additive and Linearity Properties of Upper and Lower Integrals – Riemann's Conditions.

Chapter 7: Sections 7.1 to 7.13 (Omit 7.8) **(20 hrs)**

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 -Second Mean value theorem for Riemann integrals, Lebesgue's criterion for the existence of Riemann integrals.

Chapter 7: Sections 7. 15 to7. 26 (Omit 7. 21, 7. 23 to 7. 25) **(20 hrs)**

UNIT IV: **Sequences 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 - Uniform convergence and Riemann - Stieltjes integration – Uniform Convergence and Differentiation-Sufficient conditions for uniform convergence of a series

Chapter 9: Sections 9.1- 9.11 (Omit 9.7 & 9.9) (18 hrs)

UNIT V: **Sequences of Functions**

Power series - Multiplication of Power series-TheTaylor's series generated by a function– Bernstein's theorem-Abel's limit theorem-Tauber's theorem.

Chapter 9: Sections 9.14 to 9.23 (Omit 9.16 to 9.18) (14 hrs)

RECOMMENDED TEXT:

Mathematical Analysis, 2nd Edition, Tom M.Apostol, Addison Wesley Publishing company Inc. New York, 1974.

REFERENCE BOOKS:

1. Real Analysis, Bartle, R.G, John Wiley and sons Inc,1976.
2. Principles of mathematical Analysis, 3rd Edition, Rudin.W, Mc Graw Hill Company, New York, 1976.
3. Principles of Real Analysis, A.L. Gupta and N.R. Gupta, Pearson Education, (India Print) 2003.
4. Understanding Real Analysis (2 edition) Paul Zorn, (2 edition) ,CRC Press,2017.
5. Elements Of Real Analysis by Shanthi Narayan and M.D Raisinghania.
6. A Second Course in Mathematical Analysis by D. Somasundaram, Narosa Publications, (2010).

JOURNALS:

1. SIAM Journal on Mathematical Analysis
2. Journal of Mathematical Analysis and Applications
3. Real Analysis Exchange
4. Journal of Real Analysis

WEBSITES AND E- LEARNING SOURCES

1. http://math-forum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. https://www.elsevier.com/mathematics

COURSE OUTCOMES : Upon Completion of this course, the students will be able to

CO No.	Course Outcome Statement
CO 1	Study on functions of bounded variation.
CO 2	Analyze and study the theory of Riemann Stieltjes Integration.
CO 3	Learn Fundamental theorem of integral calculus Mean value theorems for Riemann Stieltjes integrals
CO 4	Learn Uniform convergence and continuity with reference to sequence of functions.
CO 5	Discuss the convergence of multiplication of power series.

MAPPING OF CO WITH PSO

CO/PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	3	3	2
CO2	2	2	3	3	2
CO3	1	2	3	3	2
CO4	1	1	3	3	2
CO5	1	1	3	3	2
Average	1.2	1.4	3	3	2

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (chalk and talk, LCD projector), Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar.

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

ORDINARY DIFFERENTIAL EQUATIONS

Core - 3 **Course Code: 11SP21/1C/ODE**

Teaching Hours: 90 **Credits: 4** **L T P: 3 3 0**

Course Objectives: To enable the students to

1. Develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points.
2. Study the existence and uniqueness of the solutions of first order differential equations.
3. Introduce the students to the technique of solving various problems of engineering and science.
4. Study the concepts relating to the order and linearity of ODEs, analytic and computational solution methods for ODEs and the real-world applications of ODEs.
5. Apply differential equations to problems in engineering, physics, biology and economics.

COURSE OUTLINE:

UNIT I: Linear Differential Equations of Higher Order

Introduction- Higher order equations - A Modelling problem - Linear Independence - Equations with Constant Coefficients.

Chapter 2: Sections 2.1 to 2.5 **(15 hrs)**

UNIT II: Linear Differential Equations of Higher Order (Contd.)

Equations with variable coefficients - Wronskian - Variation of parameters - Some Standard Methods - Method of Laplace Transforms.

Chapter2: Sections 2.6 to 2.10 **(15 hrs)**

UNIT III: Solutions in Power Series

Introduction - Second order Linear Equations with Ordinary Points – Legendre Equation and Legendre Polynomials - Second Order Equation with Regular Singular Points - Properties of Bessel Functions.

Chapter 3: Sections 3.1 to 3.5 **(25 hrs)**

UNIT IV: System of Linear Differential Equations

Introduction - System of First Order Equations - Existence and Uniqueness Theorem - Fundamental Matrix - Linear Systems with Constant Coefficients - Linear Systems with Periodic Coefficients.

Chapter 4: Section 4.1 to 4.8 (Omit 4.3 & 4.6) **(20 hrs)**

UNIT V: Existence and Uniqueness of Solutions

Introduction – Preliminaries - Successive Approximations - Picard's Theorem - Some Examples.

Chapter 5: Section 5.1 to 5.5 **(15 hrs)**

RECOMMENDED TEXTBOOK:

S.G. Deo , V. Lakshmikantham ,V . Raghavendra, Text Book of Ordinary Differential Equations (2nd edition), Tata Mc Graw Hill, New Delhi, 1974

REFERENCE BOOKS:

1. Earl A. Coddingtion, An introduction to ordinary differential equations, (3rd edition), Prentice Hall of India Ltd, New Delhi1987.
2. Ordinary and Partial Differential Equations ,Dr.M.D.Raisinghania, Sixteenth Edition, S.Chand & Company PVT Limited, New Delhi, 2014.
3. George F. Simmons, Differential equations with applications and historical notes, TataMc Graw Hill, New Delhi1974.
4. N.N. Labedev, Special functions and their applications, Prentice Hall of India Ltd, New Delhi 1965.
5. W.T. Reid, Ordinary Differential equations, John Wiley and sons, New York 1974.
6. Ordinary Differential Equations, P. Hartman John Wiley and sons, New York 1974.

JOURNALS:

Journal of Differential Equations
International Journal of Differential Equation and Applications

E-LEARNING RESOURCES:

1. https://www.math.upenn.edu/~moose/240S2015/slides7-28.pdf
2. https://www.che.ncku.edu.tw/FacultyWeb/ChangCT/html/teaching/Engineering%20Math/Chapter%203.pdf
3. https://www.et.byu.edu/~vps/ET502WWW/NOTES/CH5.pdf
4. https://www.ams.org/journals/proc/1966-017-02/S0002-9939-1966-0190442-4/S0002-9939-1966-0190442-4.pdf
5. https://math.mit.edu/~hrm/18.031/class1reading.pdf

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

CO No.	CO Statement
CO1	Create and analyze mathematical models using higher order differential equations to solve application problems and solve differential equations with constant coefficients.
CO2	Use the Wronskian to determine if a set of functions is linearly independent and solve problems using methods of undetermined coefficients, reduction of the order of equation and Laplace Transform.
CO3	Evaluate power series solutions about ordinary points and regular singular points and learn the Legendre equations, Legendre polynomial and properties of Bessel functions.
CO4	Demonstrate the existence and uniqueness of solutions and understand the linear systems of equations.
CO5	Explain the method of successive approximations and Picard's theorem.

MAPPING – Course Outcomes With Programme Specific Outcomes

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	1	3
CO2	1	3	3	1	3
CO3	3	2	3	1	3
CO4	3	3	3	1	2
CO5	2	3	3	1	3
Average	**2.4**	**2.8**	**2.8**	1	**2.8**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (Chalk and Talk-OHP-LCD), Quiz- Seminar, Peer Learning, Assignments

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K4, K5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
Total				100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

GRAPH THEORY

Core - 4 **Course Code: 11SP21/1C/GTY**

Teaching hours: 90 **Credits: 4** **L T P: 3 3 0**

Course Objectives: This course will enable the students

1. To have knowledge about graphs, its structure and a few applications.
2. To understand Trees and Connectivity.
3. To identify Euler tours, Hamilton Cycles and Matchings.
4. To study about colourings and its characterization.
5. To explore and study more about the nature and properties of Planar graphs

COURSE OUTLINE:

UNIT 1 : Graphs and Subgraphs, Trees

Graphs and simple graphs – Graph Isomorphism – The Incidence and Adjacency Matrices – Sub graphs – Vertex Degrees – Paths and Connection – Cycles - Trees -Cut edges and Bonds - Cut vertices - Cayley's formula.

Chapter 1: Sections 1.1 – 1.7

Chapter 2: Sections 2.1 - 2.4 **(15 hours)**

UNIT 2: Connectivity, Euler Tours And Hamilton Cycles

Connectivity - Blocks - Euler Tours- Hamilton Cycles

Chapter 3: Sections 3.1, 3.2 **(20 hours)**

Chapter 4: Sections 4.1, 4.2, 4.3

UNIT 3: Matchings, Edge Colourings

Matchings – Matchings and Coverings in Bipartite graphs – Perfect Matchings - Edge chromatic number -Vizing's theorem

Chapter 5: Sections 5.1, 5.2, 5.3

Chapter 6: 6.1, 6.2 **(20 hours)**

UNIT 4: Independent sets and Cliques, Vertex Colourings

Independent sets –Ramsey's theorem - Chromatic number - Brook's Theorem – Hajos' conjecture.

Chapter 7: Sections 7.1, 7.2

Chapter 8: Sections 8.1, 8.2, 8.3 **(20 hours)**

UNIT 5: Planar Graphs

Plane and planar graphs - Dual Graphs - Euler's formula - The five colour theorem and the four colour conjecture.

Chapter 9: Sections 9.1 - 9.6 (Omit 9.4 and 9.5) **(15 hours)**

RECOMMENDED TEXT:

Graph theory and its applications - J. A. Bondy and U.S.R.Murty,5th Print, 1982.

REFERENCE BOOKS:

1. Doughlas B. West, Introduction to Graph Theory –Second edition, PHI learning pvt. ltd, 2011.
2. A. Gibbons, Algorithmic Graph Theory, Cambridge University Press, Cambridge,1989.
3. S. A. Choudum, A First Course in Graph Theory, MacMillan IndiaLtd, 1987.
4. Richard J.Trudeau, Introduction to Graph Theory (Dover Books on Mathematics) Paperback – 9 Feb 1994.
5. Gary Chartrand, Ping Zhang, A First Course in Graph Theory, courier Corporation, 2012.

Journals:

1. Discrete Mathematics- Elsevier publications
2. Journal of Graph Theory
3. Electronic journal of Graph Theory and Applications

Websites and e- learning sources

http://www.graphtheorysoftware.com
https://www.britannica.com/topic/graph-theory
http://www.elsevier.com/mathematics
https://onlinelibrary.wiley.com /journal/10970118
https://www.ejgta.org

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

CO No.	CO Statement
CO 1	analyze various types of graphs and identify bipartite graphs and examine and identify properties of trees.
CO 2	find out and determine vertex and edge connectivity of all simple graphs to explore Hamiltonian, Eulerian graphs.
CO 3	apply the analytical techniques and theoretical knowledge in solving many real life problems. To prove theorems related matching and edge coluring.
CO 4	To study about Independent sets and Ramsey's numbers and to solve and analyze the vertex colouring problem.
CO 5	apply Euler's formula and Four Colour Conjecture in various problems and in many practical situations.

Mapping of CO with PSO

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	2	2	2
CO3	3	2	2	2	2
CO4	3	2	2	2	2
CO5	3	2	2	2	2
Average	**3**	**2**	**2.2**	**2.2**	**2.2**

Key : **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

TEACHING METHODOLOGY:

Lecture(Chalk and Talk – OHP – LCD), Problem Solving, Group Discussion, Quiz, Seminar, Peer Learning.

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

MATHEMATICAL STATISTICS - I

Elective -1 **Course Code: 11SP21/1E1/MS1**

Teaching hours: 60 **Credits: 3** **L T P: 2 2 0**

COURSE OBJECTIVES:

1. To learn the significance of characteristic functions.
2. To study about various discrete and continuous type distributions.
3. To understand about special cases of limit theorems.
4. To understand more about the limit theorems pertaining to limit distribution function.
5. To learn the importance of the theory of Markov Stochastic processes.

COURSE OUTLINE:

UNIT I : Characteristic Functions

Properties of characteristic functions-The characteristic functions and their moments- Semi- invariants- The characteristic function of the sum of independent random variables-Determination of the distribution function by the characteristic functions-The characteristic function of multidimensional random vectors-Probability generating functions.

Chapter 4: Sections : 4.1 to 4.7 **(12 hrs)**

UNIT II : Some Probability Distributions

One-point and two -point distributions-The Bernoulli scheme. The Binomial Distribution- The Polya and hypergeometric distributions-The Poisson distribution-The uniform distribution-The normal distribution-The Gamma distribution-The Beta distribution-The Cauchy and Laplace distributions.

Chapter-5: Sections : 5.1 to 5.10 (omit 5.3) **(12 hrs)**

UNIT III : Limit Theorems

Preliminary remarks - Stochastic convergence - Bernoulli's law of large numbers - The convergence of a sequence of distribution functions - The Riemann-Stieljies integral - The Levy - Cramer theorem.

Chapter 6: Sections 6.1 to 6.6 **(12 hrs)**

UNIT IV: Limit Theorems (Contd.)

The De-Moivre - Laplace Theorem – The Lindberg-Levy Theorem- The Lapunov Theorem-The Gnedenko Theorem-Poisson's, Chebychev's and Khintchin's laws of Large numbers-The strong law of large numbers.

Chapter 6 : Sections 6.7 to 6.12 **(12 hrs)**

UNIT V: Markov Chains

Preliminary remarks-Homogeneous Markov chains-The transition matrix-The Ergodic theorem-Random variables forming a homogeneous Markov chain.

Chapter 7: Sections 7.1 to7.5 **(12 hrs)**

RECOMMENDED TEXTBOOK:

Marek.Fisz, Probability Theory and Mathematical Statistics, (3rd Edition) John Wiley and sons, New York, 1963.

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.
3. Y. S. Chow and H. Teicher, Probability Theory, Springer Verlag. Berlin, 1988 (2nd Edition).
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, 1986 (2nd 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.
8. J. P. Romano and A.F. Siegel, Counter Examples in Probability and Statistics, Wadsworth and Brooks / Cole Advanced Books and Software, California, 1968

JOURNALS:

1. Journal of Mathematics and Statistics, Science Publications.
2. International Journal of Mathematics and Statistics™
3. The Mathematics Intelligencer .
4. Mathematics News letter.

E-LEARNING RESOURCES:

1. https://nptel.ac.in/courses/108106083/lecture26_CF.pdf
2. https://en.wikipedia.org/wiki/Poisson_binomial_distribution
3. https://www.math.uh.edu/~climenha/blog-posts/ergodic-theorem.pdf
4. https://www.math.unl.edu/~sdunbar1/ProbabilityTheory/Lessons/BernoulliTrials/DeMoivreLaplaceCLT/demoivre
5. http://www.math.uchicago.edu/~may/VIGRE/VIGRE2007/REUPapers/FINALFULL/Casarotto.pdf

COURSE OUTCOMES: Upon Completion of this course, the students will be able to

CO No.	CO STATEMENT
CO 1	Investigate the expected value of certain function of a random variable.
CO 2	Analyze some probability distributions of special importance in either theory or practice.
CO 3	Apply the limit theorems in problems.
CO 4	Explain the significance of the law of large numbers.
CO 5	Apply the knowledge of Markov chain in the problems.

MAPPING-COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	1	2	2	2
CO2	1	3	2	2	2
CO3	2	2	2	2	2
CO4	3	2	3	2	2
CO5	3	2	2	2	2
Average	**2.2**	**2**	**2.2**	**2**	**2**

Key: **S**trongly Correlated-3 **M**oderately Correlated-2**w**eakly Correlated-1 **N**o Correlation-0

TEACHING METHODOLOGY: Lecture (Chalk and Talk-OHP-LCD) Problem Solving-Group Discussion, Quiz-Seminar

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

SEMESTER II COURSE PROFILE - M. Sc Mathematics

Course Title & Course Code	Credits	Hours/week	Total Hours	L	T	P	C.A	S.E	Total	Page No
Algebra- II 11SP21/2C/AL2	4	5	75	3	2	0	40	60	100	**26**
Real Analysis-II 11SP21/2C/RA2	4	5	75	3	2	0	40	60	100	**29**
Partial Differential Equations 11SP21/2C/PDE	4	5	75	3	2	0	40	60	100	**32**
Mechanics and Tensor Analysis 11SP21/2C/MTA	4	5	75	3	2	0	40	60	100	**35**
Mathematical Statistics -II 11SP21/2E2/MS2	3	4	60	2	2	0	40	60	100	**38**
Mathematics for Competitive Examinations 11SP21/2E/MCE	3	4	60	2	2	0	40	60	100	**41**
Language and Communication in English (Soft Skills) PG21/2S/LCE PG21/2S/FRE PG21/2S/GER	2	2	30						50	
Internship (during summer vacation)	2	**Min. 21 days**								**44**

SEMESTER – II

ALGEBRA –II

Core - 5 **Course Code: 11SP21/2C/AL2**

Teaching Hours: 75 **Credits: 4** **L T P: 3 2 0**

Course Objectives: To enable the students

1. To impart important Applications in the Theory of Numbers
2. To impart knowledge on Galois Group.
3. To emphasize the aspects of Field Theory.
4. To get introduced to Finite Fields.
5. To get the knowledge of Frobenius Theorem, Integral Quaternion's and Four- Square Theorem.

COURSE OUTLINE:

UNIT I : Fields

Extension Fields

Chapter 5 : Section 5.1 **(12hrs)**

UNIT II : Fields (contd.)

Roots of Polynomials - More About Roots

Chapter 5: Sections 5.3 and 5.5 **(18hrs)**

UNIT III : Fields (contd.)

The Elements of Galois Theory - Solvability by Radicals.

Chapter 5: Sections 5.6 and 5.7
(Omit Lemma 5.7.1, Lemma 5.7.2., Theorem 5.7.1) **(18hrs)**

UNIT IV: Finite Fields

Finite Fields - Wedderburn's Theorem on Finite Division Rings.

Chapter 7: Sections 7.1 and 7.2
(Omit Lemma 7.2.1,7.2.2 and Theorem7.2.2) **(12hrs)**

UNIT V: Finite fields(contd.)

A Theorem of Frobenius - Integral Quaternions and Four-Square theorem

Chapter 7: Sections 7.3 and 7.4 **(15hrs)**

RECOMMENDED TEXT:

I.N. Herstein, Topics in Algebra (II Edition), John Wiley & Sons, 2019.

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.Lutherand I.B.S Passi, Algebra, Vol-I Groups (1996):Vol II Rings, Narosa Publishing House, New Delhi,1999.
4. N.Jacobson, Basic Algebra, Vol I &II, Hindustan Publishing Company, NewDelhi,1974.
5. John B. Fraleigh, A First Course in Abstract Algebra, Pearson Education Publishing Company, 7th Edition, 2002.

Journals:

Journal of Algebra and its applications
Journal of Applied Mathematics
The Mathematics Intelligencer
Mathematics Newsletter.

Websites and e-Learning Sources

1. http://math-forum.org
2. http://ocw.mit.edu/ocwweb/mathematics
3. http:// www.opensource.org
4. www.algebra.com
5. https://brilliant.org/wiki/finite-fields/
6. https://nrich.maths.org/1422

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

CO No.	CO statement
CO 1	Apply the relation of one field to another.
CO 2	Discuss about roots and knows to solve problems under splitting field.
CO 3	Identify the relationship between the roots of the polynomial and its Galois group.
CO 4	Discuss all possible finite fields with important properties.
CO 5	Explain Frobenius Theorem, Integral Quaternions and Four-Square Theorem and its applications.

Mapping of CO with PSO

CO / PSO	PSO 1	PSO 2	PSO3	PS04	PSO5
CO 1	3	2	2	1	3
CO 2	2	2	2	1	3
CO 3	2	2	3	1	2
CO 4	3	2	2	1	3
CO 5	3	2	2	2	2
Average	2.6	2.0	2.2	1.2	2.6

Key: Strongly Correlated-3, Moderately Correlated-2, Weakly Correlated-1
No correlation-0

Teaching Methodology

Lecture (chalk and talk, LCD projector), Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar.

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

REAL ANALYSIS - II

Core - 6 **Course Code: 11SP21/2C/RA2**

Teaching hours: 75 **Credits: 4** **LTP: 3 2 0**

Course Objectives:

Enable the students to gain knowledge in

1. The study of Fourier series and Integrals.
2. Multivariable differential calculus.
3. The study of Implicit Function theorem and Inverse Function theorem
4. Measure theory.
5. Riemann Integrals and Lebesgue Integrals

COURSE OUTLINE:

UNIT I: Fourier Series

Introduction-Orthogonal systems 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 theorem. The convergence and Representation problems for trigonometric series-The Riemann- Lebesgue Lemma- The Dirichlet Integrals - An integral representation for the partial sums of a Fourier series - Riemann's Localization theorem. Sufficient conditions for convergence of a Fourier series at a particular point.

Chapter 11: Sections 11.1 to 11.12 **(15 hrs)**

UNIT II: **Multivariable Differential Calculus**

Introduction-The Directional derivative- Directional derivatives and continuity. The Total derivative - The total derivative expressed in terms of partial derivatives-the Matrix of a linear function - The Jacobian Matrix - The Chain rule- Matrix form of chain rule – The Mean value theorem for differentiable functions - A sufficient condition for differentiable functions - A sufficient condition for differentiability – A sufficient condition for equality of mixed Partial derivatives - Taylor's formula for functions from R^n to R^1.

Chapter 12: Sections 12.1 to 12.14 **(17 hrs)**

UNIT III: Implicit Functions and Extremum Problems

Introduction-Functions with non–Zero Jacobian determinants-The Inverse Function theorem -The Implicit Function Theorem- Extrema of Real valued functions of one variable- Extrema of real valued functions of several variables - Extremum problems with side conditions.

Chapter 13: Sections 13.1 to 13.7 **(13 hrs)**

UNIT IV: **Measure on the Real Line**

Measures on the Real line: Lebesgue outer measure - Measurable sets - Regularity – Measurable functions.

Chapter 2: Sections 2.1 to 2.4 **(15 hrs)**

UNIT V: **Integration of Functions of a Real Variable**

Integration of non-negative functions - The General integral - Riemann and Lebesgue Integrals

Chapter 3: Sections 3.1, 3.2 and 3.4 **(15 hrs)**

RECOMMENDED TEXTS:

1. Mathematical Analysis, 2nd Edition, Tom M. Apostol, Addison Wesley publishing company Inc. New York, 1974.(UNITS -I to III).
2. Measure Theory and Integration G.de. Barra, Wiley Eastern Ltd. New Delhi, 1981(UNITS –IV and V)

REFERENCE BOOKS:

1. Real Analysis, Bartle, R.G, John Wiley and sons Inc,1976.
2. Principles of Mathematical Analysis, 3rd Edition, Rudin.W, Mc.Graw Hill Company, New York, 1976.
3. Principles of Real Analysis, A.L. Gupta and N.R. Gupta, Pearson Education, (India Print) 2003.
4. Understanding Real Analysis (2nd edition) Paul Zorn.
5. Elements Of Real Analysis by Shanthi Narayan and M.D Raisinghania.
6. A Second Course in Mathematical Analysis by D. Somasundaram, Narosa Publications, (2010).

JOURNALS:

1. SIAM Journal on Mathematical Analysis
2. Journal of Mathematical Analysis and Applications
3. Journal of Real Analysis
4. Real Analysis Exchange

WEBSITES AND E- LEARNING SOURCES

http://math-forum.org
http://ocw.mit.edu/ocwweb/Mathematics
http://www.opensource.org
https://www.elsevier.com/mathematicshttp//www.opensource.org

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

CO NO.	Course Outcome Statement
CO 1	Learn convergence of the Fourier Series
CO 2	Analyze and study multivariable differential calculus
CO 3	Study Jacobians, Implicit Function theorem and Inverse Function theorem.
CO 4	Explain the notion of Measure theory
CO 5	Study Riemann and Lebesgue Integrals

Mapping of CO with PSO

CO/PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	3	2	2
CO2	2	2	3	2	2
CO3	1	2	3	2	2
CO4	1	1	3	2	2
CO5	1	1	3	2	2
Average	1.2	1.4	3	2	2

Key : **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1

No correlation-0

Teaching Methodology: Lecture (chalk and talk, LCD projector), Problem Solving, Discussion and Interactive session, Assignment, Quiz and seminar.

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

PARTIAL DIFFERENTIAL EQUATIONS

Core - 7 **Course Code: 11SP21/ 2C /PDE**

Teaching hours: 75 **Crédits: 4** **L T P: 3 2 0**

COURSE OBJECTIVES:

To enable the students to

1. Formulate physical problems mathematically and develop a systematic approach of solving partial differential equations.
2. Develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points.
3. Study the existence and uniqueness of the solutions of first order differential equations Cauchy problem, boundary value problems and method of separation of variables.
4. Use appropriate methods to solve specific problems.
5. Extract information from partial derivative models in order to interpret reality and identify real phenomena as models of partial derivative equations.

COURSE OUTLINE:

UNIT I: Mathematical models, Classification of second order equations

The classical equations - Vibrating string - Vibrating membrane - Waves in an Elastic medium - Conduction of heat in solids - The Gravitational potential - Second order equation in two independent variables - Canonical Forms - Equations with constant coefficients - General solution.

Chapter 2: Section 2.1- 2.6

Chapter 3: Section 3.1- 3.4 **(15 hrs)**

UNIT II: The Cauchy problem

The Cauchy problem- Cauchy Kowalewsky theorem - Homogeneous wave equation - Initial Boundary value problems -Finite string with fixed ends.

Chapter 4: Sections 4.1- 4.6 (omit 4.5) **(15 hrs)**

UNIT III: Method of Separation of Variables

Separation of variables - Vibrating string problem-Existing and Uniqueness of solutions of the Vibrating string problem- Heat conduction problem - The Laplace and Beam equations.

Chapter 6: Section 6.1- 6.6 (Omit 6.5) **(15 hrs)**

UNIT IV: Boundary value problems

Boundary value problems - Maximum and Minimum principles - Uniqueness and Continuity theorem - Dirichlet problem for a circle - A Circular annulus.

Chapter8: Section 8.1- 8.5 **(15 hrs)**

UNIT V: Green's function

The Delta function - Green's function - Methods of Green's function -Dirichlet problem for the Laplace & Helmholtz operators.

Chapter 10: Section 10.1 - 10.5 **(15 hrs)**

RECOMMENDED TEXTBOOK:

TynMyint-U and Lokenath Debnath, Partial Differential Equations for Scientists and Engineers (Third Edition), North Holland, New York, 1987.

REFERENCE BOOKS:

1. W.E. Williams, Partial Differential Equations, Oxford, 1990.
2. Ordinary and Partial Differential Equations , Dr.M.D.Raisinghania, Sixteenth Edition, S.Chand & Company PVT Limited, New Delhi, 2014.
3. N. Sneddon, The use of integral forms, Tata Mcgraw Hill, NewDelhi, 1985.
4. M.M.Smirnov, Second order Partial Differential Equations, NewDelhi, 1983.
5. R.Dennemayer, Introduction toPartial Differential Equations, New York, 1968.
6. M. D. Rai Singhania, Advanced Differential Equations, S.Chand& Company Ltd, NewDelhi, 2001.

JOURNALS:

Journal of Partial Differential Equation
International Journal of Partial Differential Equations and Applications
Communications in Partial Differential Equation

E-LEARNING RESOURCES:

1. https://nptel.ac.in/courses/111103021/32.pdf
2. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/46171/205_2004_Article_BF002 85433.pdf?sequence=1
3. http://staff.matapp.unimib.it/~stefanom/didattic/matematica/anSup20132014/appunti/AnalisiSuperiore.pdf

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

CO No.	CO Statement
CO 1	Develop knowledge about second order equation in two independent variables, their canonical forms and equations with constant coefficients.
CO 2	Evaluate Cauchy problem of infinite strings and finite strings with fixed ends.
CO 3	Evaluate initial boundary value problem using the method of separation of variables.
CO 4	Explain and use Dirichlet problem for a circle and circular annulus.
CO 5	Recognize the concept of Green's function and apply Green's function method to determine the Greens function solution of the Dirichlet involving the Laplace and Helmholtz operator.

MAPPING - Course Outcome with Programme Specific Outcome

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	3	3	1	3
CO2	3	3	3	1	3
CO3	3	3	3	1	3
CO4	3	3	3	1	3
CO5	3	3	3	1	3
AVERAGE	**2.8**	**3**	**3**	**1**	**3**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No Correlation-0

Teaching Methodology: Lecture (Chalk and Talk-OHP-LCD), Quiz, Seminar, Peer Learning, Assignments

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

MECHANICS AND TENSOR ANALYSIS

Core - 8 **Course Code :11SP21/2C/MTA**

Teaching hours: 75 **Credits: 4** **LTP: 3 2 0**

Course Objectives

This course will enable the students

1. To understand the fundamental concepts of Classical Mechanics.
2. To study about Hamilton's equation
3. To inculcate the concepts of Hamilton's Jacobi theory and Canonical transformation
4. To know the idea of Tensor Analysis
5. To perceive the knowledge of Christoffel's Symbols, Ricci's Theorem and Riemann Christoffel Tensor

COURSE OUTLINE:

UNIT I: Introductory Concepts - Lagrange's Equations

The Mechanical System – Generalized Coordinates – Constraints– Virtual work – Derivation of Lagrange's Equations – Examples- Integrals of the motion.

Chapter 1: Sections 1.1 - 1.4.

Chapter 2: Sections 2.1- 2.3 **(15 hrs)**

UNIT II: Hamilton's Equations

Hamilton's Principle -Hamilton's equations - Other Variational Principles.

Chapter 4: Sections 4.1- 4.3 **(15 hrs)**

UNIT III: Hamilton Jacobi Theory - Canonical Transformations

Hamilton's Principal function – The Hamilton -Jacobi Equation.

Chapter 5: Sections 5.1 & 5.2 **(15 hrs)**

UNIT IV: Tensor Theory

Scope of Tensor Analysis -Transformation of Coordinates – Properties of Admissible Transformations of Coordinates – Transformation by Invariance- Transformation by Covariance and Contravariance–The Tensor concept–Tensor character of Covariant and Contra variant laws – Algebra of Tensors -Quotient laws – Symmetric and Skew - Symmetric tensors – Relative tensors.

Chapter 2: Sections 18 - 28 **(15 hrs)**

UNIT V: Tensor Theory (Contd.,)

The Metric tensor - The Fundamental and Associated Tensors - Christoffel's Symbols – Transformation of Christoffel's.Symbols-Covariant differentiation of tensors-Formulas for Covariant Differentiation - Ricci's Theorem – Riemann Christoffel -Tensor Properties of Riemann – Christoffel Tensors.

Chapter 2: Sections 29 - 37 **(15 hrs)**

RECOMMENDED TEXTS:

1. Classical Dynamics, Donald . T. Greenwood, Prentice Hall of India, New Delhi 1985.
2. Tensor Analysis, I .S. Sokolnikoff, John Wiley and Sons, New York,1964

REFERENCE BOOKS:

1. The Mathematical Theory of Relativity, A.S.Eddington, Cambridge University Press, 1930.
2. An Introduction to Theory of Relativity, P..G..Bergman, New York, 1942.
3. Riemannian Geometry and the Tensor Calculus, C.E.Weatherburn, Cambridge University Press.
4. Tensor Calculus, U.C. De, Absos Ali Shaikh and Joydeep Sengupta, Narosa Publishing House, New Delhi, 2004.
5. Tensor Calculus, J. L. Synge and A. Schild, Toronto,1949.

Journals

1. Mechanics of Materials
2. Tensor analysis with its Applications in Mechanics he Mathematics Intelligencer .
3. Mathematics News letter.

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

CO No.	CO Statement
CO 1	Analyze about the conservation principles and Lagrangian of Classical Mechanics.
CO 2	Use the knowledge of the Hamilton's principle and Hamilton's equations.
CO 3	Compute Canonical Transformations and special transformations
CO 4	Explain the concepts of tensors and algebra of tensors.
CO 5	Describe about the Riemann Christoffel tensors and Ricci's theorem

Websites And e- Learning Sources:

1. https://nptel.ac.in/courses/115/103/115103115/
2. https://static1.squarespace.com/static/570e7b14e707ebd28d391286/t/596254a83e00be4fb1e22fb2/1499616427988/classical-9.pdf
3. http://web.mit.edu/16.61/www/pdfs/Lecture03.pdf
4. https://www.mathpages.com/rr/s5-02/5-02.html
5. https://math.stackexchange.com/questions/1400873/contraction-of-the-riemann-christoffel-tensor

MAPPING-Course Outcome with Programme Specific Outcome

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	3	2	3	2	3
CO 2	3	3	3	2	2
CO 3	2	3	3	2	2
CO 4	3	3	3	2	3
CO 5	2	3	3	2	2
Average	**2.6**	**2.8**	**3**	**2**	**2.4**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (chalk and talk, LCD projector), Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar.

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

MATHEMATICAL STATISTICS - II

Elective - 2 **Course Code: 11SP21/2E2/MS2**

Teaching hours: 60 **Credits: 3 L T P: 2 2 0**

Course Objectives: This course will enable the students

1. To learn various problems using probability theory.
2. To explore various small sample distributions.
3. To learn the importance of limit theorems.
4. To learn the applications of hypothesis testing.
5. To apply the relevant methods in estimating the unknown parameter

COURSE OUTLINE:

UNIT I: Sample Moments and their Functions

The notion of a sample-The notion of a statistic-The distribution of the arithmetic mean of the independent normally distributed random variables-The χ^2 distribution-The distribution of the statistic ($\bar{X}$,S)

Chapter 9: Sections 9.1 to 9.5 **(12 hrs)**

UNIT II: Sample Moments And Their Functions (Continued)

Student's t – distribution - Fisher's Z – distribution - The distribution of $\bar{X}$ for some non-normal populations - The distribution of sample moments and sample correlation coefficients of a two-dimensional normal population..

Chapter 9: Sections 9.6 to 9.9 **(12 hrs)**

UNIT III: Significance Tests

The concept of a statistical test - Parametric tests for small samples - Parametric tests for large samples- The χ^2 Test - Tests of the Kolmogorov and Smirnov type - The Wald-Wolfovitz and Wilcoxon-Mann-Whitney tests-Independence tests by contingency tables

Chapter 12: Sections 12.1 to 12.7 **(12 hrs)**

UNIT IV: The Theory of Estimation

Preliminary notions-consistent estimates-Unbiased estimates-The sufficiency of an estimate-The efficiency of an estimate- Asymptotically most efficient estimates – Methods of finding estimates.

Chapter 13: Sections 13.1 to 13.7 **(12 hrs)**

UNIT V: Theory of Hypothesis Testing

The power function and the OC function-Most powerful tests - Uniformly most powerful test - Unbiased tests.

Chapter 16: Sections 16.2 to 16.5 (12 hrs)

RECOMMENDED TEXTBOOK:

Marek Fisz, Probability Theory and Mathematical Statistics, (3rd edition) John Wiley and sons, New York, 1963.

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.
3. Y.S.Chow and H.Teicher, Probability Theory, Springer Verlag. Berlin, 1988 (2nd Edition)
4. R.Durrett, Probability : Theory and Examples, (2nd Edition) Duxbury Press, NewYork, 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
8. J.P. Romano and A.F. Siegel, Counter Examples in Probability and Statistics, Wadsworth and Brooks / Cole Advanced Books and Software, California, 1968

JOURNALS:

1. Journal of Mathematics and Statistics, Science Publications
2. International Journal of Mathematics and Statistics TM
3. The Mathematics Intelligencer
4. Mathematic News letter.

E-LEARNING RESOURCES:

1. https://www.le.ac.uk/users/dsgp1/COURSES/LEISTATS/Lecture8.pdf
2. https://en.wikipedia.org/wiki/Fisher%27s_z-distribution
3. https://www.statisticssolutions.com/tests-for-two-independent-samples/
4. https://www.analytics-toolkit.com/glossary/efficient-estimator/
5. https://www.stat.washington.edu/jaw/COURSES/580s/581/LECTNOTES/ch6a.pdf

COURSE OUTCOMES: Upon Completion of this course, the students will be able to

CO Number	CO STATEMENT
CO 1	Apply the methods of solving many statistical problems by means of probability theory.
CO 2	Investigate statistical problems to draw conclusions about the unknown part.
CO 3	Explain about special cases of limit theorems.
CO 4	apply the procedures of significance tests in problems
CO 5	Analyze the theory dealing with the theory of estimation to estimate the unknown parameter.

MAPPING- Course Outcome With Programme Specific Outcome

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	2	2
CO2	2	2	2	2	2
CO3	3	3	3	2	2
CO4	2	2	2	1	2
CO5	2	2	2	2	2
AVERAGE	**2.4**	**2.2**	**2.4**	**1.8**	**2**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (Chalk and Talk-OHP-LCD) Problem Solving-Group , Discussion, Quiz -Seminar.

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems- Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

MATHEMATICS FOR COMPETITIVE EXAMINATIONS

(Offered to other PG departments)

Elective – EDE 1 **Course Code: 11SP21/2E/MCE**

Teaching hours: 60 **Credits: 3 LTP: 2 2 0**

COURSE OBJECTIVES: To enable the students

1. To apply knowledge and skill in logical reasoning and problem solving.
2. To understand general aptitude techniques.
3. To identify business applications in Mathematics.
4. To know about various concepts in statistics.
5. To explore and to study the calculation of percentage, profit & loss, ratio & proportions.

COURSE OUTLINE

UNIT I: Logical Reasoning

Problems of Ages, Problem of trains, Average, Grouping, Ranking, Problems on Numbers, True discount, Banker's discount, Odd man out.

(15 hrs)

UNIT II: Logical Reasoning(contd.)

Boats and Streams, Time & Work, Time Distance.

(15 hrs)

UNIT III: Quantitative Aptitude

Percentage, Profit and Loss, Ratio and Proportions **(10 hrs)**

UNIT IV: Business Applications

Permutations &Combinations, Stocks and Shares **(10 hrs)**

UNIT V: Statistics

Basic concepts in testing of hypothesis, Type I Error and Type II error, Level of significance, ANOVA classification-One way classification and Two way classification (Only Simple Problems) **(10 hrs)**

RECOMMENDED TEXT BOOK:

Quantitative aptitude by R.S. Agarwal, S. Chand & Co, Ltd., 2007.

REFERENCE BOOKS:

1. Business Mathematics by P.R. Vittal, Margham Publicationa,1999.
2. Statistics by P.Sivarama Krishna Das, C.Vijayakumari ,Viji's academy 2010.
3. Quantitative Aptitude by U Mohan Rao , Scitech Publication, 2007.
4. Allied Mathematics by P.R.Vittal, Margham Publications, 2009.
5. A modern approach to logical reasoning R.S. Agarwal, S.Chand& Co, Ltd., 1999.

JOURNALS:

Ratio and proportion. Pmd-ncert
Aptitude made easy- Ratio and proportions-1, Basics and Methods
The Mathematics Intelligencer
Mathematic News Letter.

WEBSITES AND E-LEARNING SOURCES

1. https://drive.google.com/file/d/1s9dXa1GKombEI3-ngQdJ9tXbRQyne-D1/view
2. https://bankersway.com/quantitative-aptitude-maths-free-study-materials-pdf-competitive-exam/

COURSE OUTCOMES

Upon Completion of this course, the students will be able to

CO NO.	CO Statement
CO1	Analyse various types of problems with logical reasoning
CO2	Examine and identify the techniques
CO3	Apply the analytical techniques and knowledge in business.
CO4	Apply the formula and perform calculations through quantitative aptitude
CO5	Analyse the various concepts in statistics

MAPPING OF CO WITH PSO

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	3	3	3	2	3
CO3	3	3	2	3	2
CO4	3	2	2	3	2
CO5	3	1	2	3	3
Average	**3**	**2.2**	**2.4**	**2.6**	**2.6**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1, **N**o correlation-0

TEACHING METHODOLOGY:

Lecture (chalk and talk),Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

INTERNSHIP

Credits: 2 **Duration: 21 working days**

Students have to undergo an Internship Programme during the summer vacation immediately after the second semester and are required to submit the Internship Completion Certificate, Attendance certificate and Internship report.

Viva voce will be conducted by an Internal Examiner.

SEMESTER III COURSE PROFILE - M. Sc Mathematics

Course Title & Course Code	Credits	Hours/ week	Total Hours	L	T	P	C.A	S.E	Total	Page No
Complex Analysis-I 11SP21/3C/CA1	4	6	90	3	3	0	40	60	100	**46**
Topology 11SP21/3C/TOP	4	5	75	3	2	0	40	60	100	**49**
Differential Geometry 11SP21/3C/DGY	4	5	75	3	2	0	40	60	100	**52**
(Option 1) Advanced Operations Research 11SP21/3E3/AOR **(Option2) Fluid Dynamics** 11SP21/3E3/FDY	3	4	60	2	2	0	40	60	100	**55** **58**
(Option 1) Formal languages and Automata theory 11SP21/3E4/FAT **(Option2) Measure Theory** 11SP21/3E4/MTY	3	4	60	2	2	0	40	60	100	**61** **64**
Resource Management Techniques 11SP21/3E/RMT	3	4	60	2	2	0	40	60	100	**67**
Analytical Skills for NET/SET (Soft Skills) 11SP21/3S/ASN	2	2	30	2	0	0	-	-	50	**70**
Self Study (Optional) Special Functions 11SP21/3SS/SPF **Introduction to Machine Learning** 11SP21/3SS/MAL	2						-	-	100	**72** **75**

SEMESTER – III

COMPLEX ANALYSIS – I

Core - 9 **Course Code: 11SP21/3C/CA1**

Teaching Hours: 90 **Credits: 4 L T P: 3 3 0**

COURSE OBJECTIVES:

To enable the students to

1. Impart knowledge and skills in Cauchy integral formula and local properties of analytic functions.
2. Expose to general form of Cauchy's theorem.
3. Understand the properties of Harmonic functions on a disc and concerned results.
4. Introduce series and product developments.
5. Understand Hadamard's three circle theorem.

COURSE OUTLINE:

Unit I: Complex Integration

Line Integrals – Rectifiable arcs – Line Integrals as functions of arcs – Cauchy's Theorem for a rectangle – Cauchy's Theorem in a Disk – The index of a Point with Respect to a Closed Curve - The Integral Formula – Higher Derivatives.

Chapter 4: Section1 : 1.1 – 1.5, Section 2 : 2.1 – 2.3 (20 hrs)

Unit II: Local Properties of analytic Functions and General Form of Cauchy's Theorem

Removable Singularities – Taylor's Theorem – Zeroes and Poles – The Local Mapping – The Maximum Principle – Chains and Cycles – Simple Connectivity – Homology – The General Statement of Cauchy's Theorem – Locally Exact Differentials – Multiply Connected Regions.

Chapter 4: Section 3: 3.1 – 3.4, Section 4: 4.1 – 4.7 (20 hrs)

Unit III: Residues and Harmonic Functions

The Residue Theorem – The Argument Principle – Definition and Basic Properties – The Mean value Property – Poisson's Formula- Schwarz's Theorem – The Reflection Principle

Chapter 4: Section 5: 5.1 and 5.2, Section 6: 6.1 – 6.5 (18 hrs)

Unit IV: Power Series Expansions

Weierstrass's Theorem – The Taylor Series – The Laurent Series

Chapter 5: Section 1: 1.1 – 1.3 (12 hrs)

Unit V: Partial Fractions and Entire Functions

Partial Fractions – Infinite Products – Canonical Products – The Gamma Function– Stirling's Formula – Jensen's Formula – Hadamard's Theorem(Statement only)

Chapter 5: Section 2: 2.1 – 2.5, Section 3: 3.1, 3.2 (20 hrs)

RECOMMENDED TEXT:

Lars.V. Ahlfors, Complex Analysis (3rd Edition) Mc Graw Hill Co., New York, 2017.

REFERENCE BOOKS:

1. H. A. Priestley, Introduction of Complex Analysis, OUP Oxford publisher, 2nd Edition, 2003.
2. J. B. Conway, Functions of one complex variable I, Springer publisher, 2nd Edition, 1978.
3. E. Hille, Analytic function theory (2 Vols.), published by Cambridge University Press, 2nd Edition, 2016.
4. M. Heins, Complex function theory, Academic Press New york, 1968.
5. Tom Apostol, Introduction to Analytic Number Theory, Springer New York, 2013.

Journals

Complex Analysis and its synergies
Complex Analysis and Operator Theory
Complex Manifolds
The Mathematics Intelligencer
Mathematic News Letter

Websites and e- learning sources

1. http://math-forum.org
2. http//www.math.stackexchange.com
3. http//www.mathfaculty.fullerton.edu
4. http//www.researchgate.net
5. http//www.maths.ed.ac.uk

COURSE OUTCOMES:

Upon Completion of this course, the students will be able to

CO Number	CO STATEMENT
CO 1	Identify how analytic functions are useful in complex integration
CO 2	Find parametrizations of curves and compute line integrals directly and also solving problems involving residues
CO 3	Effectively locate and use the information needed to prove theorem and establish mathematical results
CO 4	Manipulate and use power series
CO 5	represent rational functions

MAPPING - Course Outcome with Programme Specific Outcome

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	1	2
CO2	2	2	3	1	2
CO3	3	2	2	1	1
CO4	2	2	2	1	2
CO5	2	1	1	1	2
AVERAGE	2.4	1.8	1.8	1	1.8

Key: Strongly Correlated-3, Moderately Correlated-2, Weakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (chalk and talk, LCD projector), Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

TOPOLOGY

Core - 10 **Course Code: 11SP21/3C/TOP**

Teaching hours: 75 **Credits: 4 LTP: 3 2 0**

COURSE OBJECTIVES: This course will enable the students

1. To understand about the topological spaces and continous functions.
2. To have a clear picture of connectedness and local connectedness
3. To get knowledge on compact spaces and Hausdorff spaces
4. To learn about Countability and Separation Axioms.
5. To introduce the concept of normal and metrizable spaces

COURSE OUTLINE:

UNIT I: Topological Spaces and Continuous Functions

Topological spaces, Basis for a topology, The order Topology, The product Topology on $X \times Y$, The subspace Topology, Closed sets and limit points- Continuous Functions , The Product topology, The Metric Topology.

Chapter 2: Sections : 12 – 21 **(15 hrs)**

UNIT II: Connectedness and Compactness

Connected spaces, Connected subspaces of the Real line, Components and Local Connectedness.

Chapter 3: Sections :23 – 25 **(15 hrs)**

UNIT III: Connectedness and Compactness (Contd.)

Compact spaces, Compact subspaces of the Real line, Limit point Compactness, Local Compactness.

Chapter 3: Sections:26 - 29 **(15 hrs)**

UNIT IV: **Countability and Separation Axioms**

The Countability Axioms,The separation Axioms, Normal spaces.

Chapter 4 : Sections : 30 - 32 **(15 hrs)**

UNIT V:Countability and Separation Axioms(Contd.)

The Urysohn Lemma, The Urysohn Metrization Theorem, The Tietze Extension Theorem.

Chapter 4: Sections : 33 - 35 **(15 hrs)**

RECOMMENDED TEXT:

James R. Munkres, Topology, Second Edition, Prentice – Hall of India Pvt. Ltd., New Delhi, 2002.

REFERENCE BOOKS

1. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2015.
2. Bert Mendelson, Introduction to Topology, 3rd edition, Dover Publications Inc., New York, 1990.
3. Fred H. Croom, Principles of Topology, Dover Publications Inc., New York, 2016.
4. Walter Rudin, Functional Analysis, McGraw - Hill Inc., New York, 2nd edition 1991.
5. George Bachman and Lawrence Narici, Functional Analysis, Dover Publications Inc., New York, 2000.

Periodicals

The Mathematics Intelligencer.
Mathematics Newsletter.
Journal of topology and analysis
Topology and its applications.

Websites and e-Learning

1. https://nptel.ac.in/courses/111/106/1111060
2. https://www.sciencedirect.com/science/article/pii/S0166864112003331
3. https://faculty.etsu.edu/gardnerr/5357/notes/Munkres-Chapter4 intro.pdf
4. http://mathonline.wikidot.com/bases-of-a-topology

COURSE OUTCOMES:

Upon Completion of this course, the students will be able to

CO NO	COURSE OUTCOME STATEMENT
CO 1	Outline terms, definitions and theorems related to topology.
CO 2	Use continuous functions and homeomorphisms to understand connectedness and local connectedness
CO3	Demonstrate knowledge and understanding of compact spaces and Hausdorff spaces
CO4	Discuss and illustrate the concepts of the countability and separation axioms
CO5	Explain a selection of theorems concerning normal and metrizable spaces,

Mapping Course Outcome with Programme Specific Outcome

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	2
CO2	3	3	3	2	2
CO3	3	2	3	2	2
CO4	3	2	2	2	2
CO5	3	2	2	2	2
Average	3	2.4	2.4	2	2

Key: **S**trongly Correlated-3,**M**oderately Correlated-2,**W**eakly Correlated-1

No correlation-0

TEACHING METHODOLOGY:

Lecture(chalk and talk, LCD projector), Problem Solving,

Discussion and Interactive session, Assignment, Quiz, Seminar

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

DIFFERENTIAL GEOMETRY

Core - 11 **Course Code:11SP21/3C/DGY**

Teaching hours: 75 **Credits: 4** **LTP: 3 2 0**

Course Objectives

1. To introduce space curves and the intrinsic properties of surface and geodesics.
2. To derive the theorem for Fundamental theorem for space curves.
3. To have the knowledge about Non intrinsic properties of surface.
4. To derive the Involutes and Evolutes of curves.
5. To derive the Differential equations for geodesic.

COURSE OUTLINE:

UNIT I: Space Curves: Definition of Space Curve - Arc length - tangent, normal and binormal - Curvature and Torsion of a curve given as the intersection of two surfaces.
Chapter 1: Sections 1 to 5. **(15 hrs)**

UNIT II: Contact between Curves and surfaces - Tangent surface - Involutes and Evolutes - Intrinsic equation - fundamental existence theorem for space curves - Helices.
Chapter 1: Section 6 to 9. **(15 hrs)**

UNIT III: Intrinsic properties of a surface: Definition of a surface - Curves on a Surface - Surface of revolution - Helicoids - Metric - Direction Coefficients.
Chapter 2: Sections 1 to 6. **(15 hrs)**

UNIT IV: Families of curves - Geodesics - Canonical Geodesic equations – Normal property of Geodesics
Chapter 2: Section 7, 10 to 12. **(15 hrs)**

UNIT V: Geodesic Parallel – Geodesic curvature - The Second Fundamental form - Principal curvatures – Lines of Curvature
Chapter 2: Sections 14, 15 & Chapter 3: Sections 1, 2, 3. **(15 hrs)**

RECOMMENDED TEXT

T.J. Willmore, An introduction to Differential Geometry Oxford University Press (17^{th} Impression) New Delhi – 2001.

REFERENCE BOOKS

1. Struik, D.J. Lectures on Classical Differential Geometry 2nd edition, Dover Publications, 2012.
2. Mittal & Agarwal, Differential Geometry, Krishna Prakasham Media Pvt. Ltd., 27th Edition 2014.
3. S.G. Venkatachalapathy, Differential Geometry, Margam Publications, 2007
4. Rohit Garg A, Basics of Differential Geometry, Anmol Publications Pvt. Ltd., 2011.
5. D. Somasundaram, Differential Geometry Narosa Publishing Housing ltd, 2005.

JOURNALS

Differential geometry and its applications

Journal of differential geometry

The Mathematics Intelligencer

Mathematics News letter.

WEBSITES AND e-LEARNING SOURCES

1. https://www.math.upenn.edu/~siegelch/Notes/diffgeo.pdf
2. http://math.uchicago.edu/~may/REU2017/REUPapers/Cruz.pdf
3. http://uregina.ca/~mareal/cs2.pdf
4. https://fsw01.bcc.cuny.edu/luis.fernandez01/web/texts/dgcs.pdf

COURSE OUT COMES: Upon Completion of this course, the students will be able to

CO No.	CO Statement
CO 1	Explain the concept of 3D in Serret Frenet formula.
CO 2	Explain the fundamental Existence theorem for space curves.
CO 3	Analyze the concept of anchor rings, helicoids, surface of revolution.
CO 4	Establish basic properties of geodesics, evolutes and minimal surfaces.
CO 5	Evaluate the principal curvatures, the mean curvature and Gauss curvature of a given surface.

MAPPING – Course Outcome With Programme Specific Outcome

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	2	3	3	4	3
CO 2	2	2	3	2	2
CO 3	2	2	3	2	2
CO 4	2	2	3	2	2
CO 5	2	2	3	2	2
Average	**2**	**2.2**	**3**	**2.2**	**2.2**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology:

Lecture (Chalk and Talk LCD), Problem Solving, Seminar
Peer Learning

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

Elective Paper (Option 1)

ADVANCED OPERATIONS RESEARCH

Elective - 3 **Course Code: 11SP21/3E3/AOR**

Teaching hours: 60 **Credits: 3** **L T P: 2 2 0**

Course Objectives: This course will enable the students

1. To apply cutting plane methods to obtain optimal integer solution values of variables in a Linear Programming.
2. To develop problem solving and decision making skill to optimum effect.
3. To understand the meaning of inventory control as well as various forms and functional role if inventory.
4. To realize the need to study replacement and maintenance analysis techniques.
5. To make distinction between linear programming and dynamic programming approaches for solving a problem and to provide a quantitative approach for effective decision making.

COURSE OUTLINE:

UNIT I: Integer Linear Programming

Introduction – Types of Integer Programming Problems – Enumeration and Cutting Plane Solution Concept – Gomory's All Integer Cutting Plane Method – Gomory's Mixed – Integer Cutting Plane Method.

Chapter 7: Sections 7.1 - 7.5 **(12 hrs)**

UNIT II: Decision Theory and Decision Trees

Introduction – Steps of Decision Making Process – Types of Decision Making Environments – Decision Making Under Uncertainty - Decision Making Under Risk - Decision Tree Analysis.

Chapter 11: Sections 11.1 - 11.5, 11.7 **(10 hrs)**

UNIT III: Deterministic inventory Control Models

Introduction – The meaning of inventory Control – Functional role of Inventory – Reasons for Carrying Inventory – Factors Involved in Inventory Problem Analysis – Inventory Model Building – Single Item Inventory Control Model without shortages – Single Item Inventory Control Model with Shortages.

Chapter 14: Sections 14.1 - 14.8 **(12 hrs)**

UNIT IV: Replacement and Maintenance Models

Introduction – Types of Failure- Replacement of Items Whose Efficiency Deteriorates with Time.

Chapter 17: Sections 17.1 - 17.3 **(10 hrs)**

UNIT V: Dynamic Programming

Introduction – Dynamic Programming Terminology – Developing Optimal Decision Policy - Dynamic Programming under Certainty.

Chapter 22: Sections 22.1 - 22.4 **(16 hrs)**

RECOMMENDED TEXT:

J. K. Sharma, Operations Research Theory and Applications, 4th edition, Macmillan Publishers India Ltd, 2009.

REFERENCE BOOKS :

1. Handy A. Taha Operations Research (9th Edition), Pearson Publishers, New Delhi, 2013.
2. S.D. Sharma, Operations Research,16th Revised Edition, Kedar Nath Ram Nath and Co., Meerut, 2010.
3. Frederick. S. Hiller and Gerald J. Liberman, Introduction to Operations Research (8th Edition), 2014.
4. Kanti Swarup, P. K. Gupta, Man Mohan, Operations Research, Sultan Chand & sons, 19th edition, 2021.
5. Ronald L. Rardin, Optimization in Operations Research, Pearson Paperback, 2018.

Periodicals

The Mathematics Intelligencer
Mathematics Newsletter.
American Journal of Operations Research
International Journal of Operations Research and Information Systems RAIRO - Operations Research

Websites and e-Learning Sources

1. https://web.mit.edu/15.053/www/AMP-Chapter-09.pdf
2. https://www.mindtools.com/dectree.html
3. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000025MS/P001336/M010144/ET/ 1527249935E-textofChapter5Module1.pdf
4. https://www.youtube.com/watch?v=G7JbHoP9I7I
5. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000025MS/P001336/M010157/ET/ 1527250760E-textofChapter8Module1.pdf

Course Outcomes: This course will enable the students to

CO No.	CO Statement
CO 1	Solve Integer Programming by Gomory's cutting plane method
CO 2	Able to construct decision trees for making accurate decision
CO 3	Analyze the need of inventory and to determine an optimum level of inventory.
CO 4	Identify, explain and evaluate the replacement and maintenance problems.
CO 5	Solve Linear programming problem using the dynamic programming approach.

Teaching Methodology: Lecture (chalk and talk, LCD projector), Problem Solving, Assignment, Seminar.

Mapping of CO with PSO

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	3	2	3	2	3
CO 2	2	3	3	3	3
CO 3	3	3	2	2	3
CO 4	3	3	3	2	3
CO 5	2	2	3	2	3
Average	**2.6**	**2.6**	**2.8**	**2.2**	**3**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

ELECTIVE PAPER (Option 2)

FLUID DYNAMICS

Elective - 3 **Course Code: 11SP21/3E3/FDY**

Teaching Hours: 60 **Credits: 3** **L T P: 2 2 0**

COURSE OBJECTIVES:

To enable the students to

1. understand the basic techniques and results of the Fluid dynamics
2. familiarize with the properties of fluids and the applications of fluid mechanics.
3. understand the concept of fluid measurement, types of flows and dimensional analysis
4. formulate important results and theorems
5. use the theory, methods and techniques of fluid dynamics to solve problems

COURSE OUTLINE:

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 - Velocity potential – The vorticity Vector - Local and particle rates of change - Equation of continuity – Worked examples.

Chapter 2: Section 2.1 to 2.8 **(12 hrs)**

UNIT II: Equations of motion of a fluid

Pressure at a point in a 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 .

Chapter 3: Section 3.1 to 3.4 **(12 hrs)**

UNIT III: Some three dimensional flows

Introduction- Sources, sinks and doublets - Images in a rigid infinite plane – Axi- symmetric flows; Stoke's stream function

Chapter 4: Section 4.1 to 4.3 & 4.5 **(12 hrs)**

UNIT IV: Some two dimensional flows

Meaning of two dimensional flow - Use of Cylindrical polar coordinates - The stream function - The Complex potential for two dimensional , irrotational incompressible flow - The Milne Thompson circle Theorem.

Chapter 5: Section 5.1 to 5.4, 5.8 **(12 hrs)**

UNIT V: Viscous flows

Stress components in a real fluid. - Relations between Cartesian components of stress-Translational motion of fluid element - The rate of strain quadric and principle stresses - Some further properties of the rate of strain quadric - The Navier – Stoke's equations of motion of a Viscous fluid.

Chapter 8: Section 8.1 to 8.5 & 8.9 **(12 hrs)**

Recommended Text

F. Chorlton, Text Book of Fluid Dynamics ,CBS Publishers and Distributors, Delhi, 1985.

Reference Books

1. R.W. Fox and A.T. McDonald. Introduction to Fluid Mechanics, Wiley, 8th edition, 2010.
2. B.S. Massey, J.W. Smith and A.J.W. Smith, Mechanics ofFluids, Taylor and Francis, New York, 9th edition, 2019
3. P. Orlandi, Fluid Flow Phenomena, Kluwer, Springer, New York, 2006.
4. M.D. Raisinghania, Fluid Dynamics, S. Chand Publishing, 5th edition, 2003.

Periodicals:

International journal of computational fluid dynamics
Structural analysis of axisymmetric solids/AIAA Journal
Journal of applied fluid mechanics- SCI mago

Websites and e-Learning Sources:

1. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/immiscible-fluid
2. https://onlinecourses.nptel.ac.in/noc21_me45/preview
3. https://www.sciencedirect.com/topics/physics-and-astronomy/three-dimensional-flow
4. https://nptel.ac.in/courses/112/104/112104118/
5. https://en.wikipedia.org/wiki/Navier%E2%80%93Stokes_equations

COURSE OUTCOMES : Upon Completion of this course, the students will be able to

CO NO	COURSE OUTCOME STATEMENT
CO 1	Identifies the values of fluid properties and relationship between them and understands the principles of continuity, momentum, and energy as applied to fluid motions.
CO 2	Understands the pressure of fluids at rest and at all points.
CO3	Uses the condition at a boundary of immiscible fluids to solve problems.
CO4	Predicts physical parameters that influence the flow in fluid mechanics.
CO5	Knows the relation between Cartesian components of stress.

MAPPING – Course Outcome With Programme Specific Outcome

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	1
CO2	2	2	1	1	1
CO3	2	2	1	1	2
CO4	1	1	2	1	2
CO5	2	2	1	1	2
Average	**1.8**	**1.6**	**1.2**	**1**	**1.6**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (Chalk and Talk LCD) Problem Solving, Seminar, Peer Learning

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

ELECTIVE PAPER (Option 1)

FORMAL LANGUAGES AND AUTOMATA THEORY

Elective - 4 **Course Code:11SP21/3E4/FAT**

Teaching Hours: 60 **Credits: 3 LTP: 3 2 0**

COURSE OBJECTIVES

To enable the students to

1. Acquire fundamental understanding of the core concepts in Automata theory and formal languages.
2. Design grammars and automata for different language classes.
3. Describe the types of grammar and derivation tree.
4. Prove or disprove theorems in automata theory using its properties.
5. Study in detail the push down automata

COURSE OUTLINE

UNIT I:
Phrase - structure languages.
Chapter 2 **(10hrs)**

UNIT II:
Closure operations
Chapter 3 **(10hrs)**

UNIT III: Context free languages
Generation trees – ambiguity - Auxiliary Lemmas.

Chapter 4 Sections 4.1 - 4.3. **(15hrs)**

UNIT IV : Finite State Automata
Definitions - Finite Automata and regular sets, Closure properties.

Chapter 5 Sections 5.1 - 5.3. **(15hrs)**

UNIT V : Push down Automata
Introduction-Informal description -Formal définitions- Characterization

Chapter 6 Sections 6.1 – 6.4 **(10 hrs)**

RECOMMENDED TEXT :

Formal languages and Automata, Rani Sironmoney, The Christian Literature Society, 1984.

REFERENCE BOOKS:

1. Introduction to Formal Languages and Automata by Peter and Linz, Fifth Edition University of California at Davis 2012.
2. Introduction to Automata Theory, Languages and Computation, John E. Hopcraft and Jeffrey D. Ullman and Rajeev Motwani, 3rd Edition, Pearson Education, New Delhi, 2008.
3. Formal Languages and Automata Theory, Sunitha K.V.N, N. Kalyani 1st Edition, Pearsons Publishers, Chennai, 2015.

JOURNALS:

1. Journal of Automata, Languages and Combinatorics.
2. International Journal of Foundations of Computer Science.

WEBSITES AND e-LEARNING SOURCES:

1. https://www.cs.odu.edu/~zeil/cs390/latest/Public/fsa/index.html
2. https://nptel.ac.in/courses/111103016
3. https://www.includehelp.com/toc/regular-sets-and-their-properties-in-theory-of-computation.aspx
4. https://www.javatpoint.com/context-free-grammar

COURSE OUTCOMES: Upon successful completion of Students will be able to

CO Number	CO statement
CO 1	Explain and manipulate the different concepts in automata theory and formal languages.
CO 2	Design regular expressions or generating a certain language.
CO 3	Simplify context-free grammars
CO 4	Determine if a certain word belongs to a language.
CO 5	Explain the power and the limitations of regular languages and context-free languages.

MAPPING - Course Outcome With Programme Specific Outcome

CO / PSO	PSO 1	PSO 2	PSO3	PSO 4	PSO5
CO1	2	2	2	3	2
CO2	2	2	2	2	2
CO3	2	2	2	3	2
CO4	2	2	2	3	2
CO5	2	2	2	3	2
Average	2	2	2	2.8	2

Key : Strongly Corelated-3 **M**oderately Corelated-2 **W**eakly Corelated-1

No corelation-0

TEACHING METHODOLOGY:

Lecture (chalk and talk), Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100

ELECTIVE PAPER (Option 2)

MEASURE THEORY

Elective : 4 **Course Code :11SP21/3E4/MTY**

Teaching Hours: 60 **Credits: 3 LTP: 3 2 0**

COURSE OBJECTIVES

To enable students to

1. Understand basics in Lebesgue measure and integration.
2. Introduce Borel sets and Hausdorff measure.
3. Know about integration with respect to measure.
4. Have knowledge on convergence in measure.
5. Understand integration in Product space.

UNIT I :The Lebesgue Integral:

The class of Lebesgue - integrable functions on a general interval-Basic properties of the Lebesgue integral - Lebesgue integration and sets of measure zero.

Book 1: Chapter 10: Sections: 10.6, 10.7, 10.8 (15 hrs)

UNIT II: Measure on a Real Line:

Measurable sets on the real line -The Lebesgue integral over arbitrary subsets of R- Lebesgue integrals of complex valued functions - Borel and Lebesgue measurability- Hausdorff measures on the real line.

Book 1: Chapter 10: Sections: 10.18, 10.19, 10.20

Book 2: Chapter 2: Sections: 2.5, 2.6 (15 hrs)

UNIT III: Abstract Measure Spaces:

Measures and Outer Measures – Measure Spaces – The L^p Spaces – Convex functions.

Book 2: Chapter 5: 5.1, 5.5, 5.6; Chapter 6: 6.1, 6.2 (10 hrs)

UNIT IV: Convergence

Convergence in Measure - Almost Uniform Convergence - Counter examples.

Book 2: Chapter 7: Sections: 7.1, 7.2, 7.4 (10 hrs)

UNIT V: Lebesgue – Stieltjes integration:

Lebesgue - Stieltjes Measure, Applications to Hausdorff Measure, Absolutely Continuous Functions **(10 hrs)**

Book 2: Chapter 9: Sections: 9.1, 9.2, 9.3

RECOMMENDED TEXTS:

1. Tom Apostol, Mathematical Analysis,2nd edition, Narosa Publishing House Pvt., Ltd., 2002.
2. G.de Barra, Measure Theory and Integration, New Age International Publishers, 2009.

REFERENCE BOOKS:

1. H.L. Royden, P.M. Fitzpatrick, RealAnalysis, Pearson Education, India, 2015.
2. W. Rudin, Real and Complex Analysis, Mc Graw Hill Book Company, 3rd edition,1987.
3. Richard R. Goldberg, Method of Real Analysis, Oxford and IBH Publishing Company Pvt., Ltd., New Delhi.
4. Robert G. Bartle, The Elements of Integration and Lebesgue Measure, John Wiley and sons, Inc, New York.
5. Alan J.Weir,Lebesgue Integration and Measure, Cambridge University Press, 1973. (Available in Google Books)

PERIODICALS:

The Mathematics Intelligencer.

Mathematics News Letter.

WEBSITESAND E-LEARNING SOURCES:

1. https://www.math.ucdavis.edu/~hunter/measure_theory/measure_theory.html
2. http://mathworld.wolfram.com/MeasureTheory.html
3. http://mathworld.wolfram.com/LebesgueMeasure.html
4. http://mathworld.wolfram.com/ProductMeasure.html
5. https://www.sciencedirect.com/topics/mathematics/hausdorff-measure

Course Outcomes:

Upon completion of this course the student will be able to

CO Number	CO statement
CO 1	Analyse the difference between Riemann integral and Lebesgue integral.
CO 2	Distinguish the relation between the class of Borel sets and the class of Lebesgue measurable sets.
CO 3	Extend the measure on a ring of sets to one on a generated σ-ring.
CO 4	Use the convergence of measurable functions in the theory of Probability.
CO 5	Compute multiple integrals which deals with measure and integration on the Cartesian product of spaces.

MAPPING – Course Outcome With Programme Specific Outcome

CO/PSO	PSO1	PSO2	PSO3	PS04	PSO5
CO1	1	2	2	1	3
CO2	1	2	2	1	1
CO3	1	1	2	1	1
CO4	1	1	1	1	2
CO5	2	1	1	1	2
Average	**1.2**	**1.4**	**1.6**	**1**	**1.8**

Key : **S**trongly Correlated-3,**M**oderately Correlated-2,**W**eakly Correlated-1
No correlation-0

Teaching Methodology Lecture (chalk and talk), Problem Solving, Discussion and Interactive session, Assignment, Seminar.

Template–End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

RESOURCE MANAGEMENT TECHNIQUES

(Offered to other PG departments)

Elective – EDE 2 **Course Code: 11SP21/3E/RMT**

Teaching hours: 60 **Credits: 3** **LTP: 2 2 0**

COURSE OBJECTIVES

To enable the students

1. To have knowledge and skill in the basics of Linear Programming Problem.
2. To learn and formulate the maximization and minimization problems through various techniques.
3. To introduce applications in transportation problem.
4. To study various concepts in sequencing problems.
5. To study and apply PERT techniques.

COURSE OUTLINE:

UNIT I : LINEAR PROGRAMMING PROBLEM
Formulation - Maximization Problems and Minimization problems - Solutions by Graphical Method (simple problems).
Section 2 **(10 hrs)**

UNIT II: TRANSPORTATION PROBLEM
Northwest Corner Rule - Least Cost Method - Vogel's Approximation Method – Modi Method (degeneracy excluded)

Section 7 **(15 hrs)**

UNIT III: ASSIGNMENT PROBLEM
Hungarian Assignment Method (balanced problem and unbalanced problem)
Section 8 **(10 hrs)**

UNIT IV: SEQUENCING PROBLEMS
Introduction - Sequencing Problems - General Assumptions - Sequencing decision problems for n jobs on two machines and three machines.
Section 14 (omit 14.6, 14.7) **(10 hrs)**

UNIT V: SCHEDULING BY PERT AND CPM
Introduction - Basic terminologies – Rules for constructing a project network – Network Computations – Floats – Programme Evaluation Review technique (PERT).
Section 15 (omit 15.7, 15.8, 15.9) **(15 hrs)**

RECOMMENDED TEXT

V. Sundaresan, K.S. Ganapathy Subramanian, K. Ganesan, Resource Management Techniques, AR Publications, Chennai (2005).

REFERENCE BOOKS

1. S. Kalavathy, Operations Research, 2nd edition, Vikas publishing house Pvt. Ltd., 2008.
2. D. S.Hira & Prem Kumar Gupta, Operations Research , S. Chand & Company Ltd., Revised edition, 2008.
3. P.R.Vittal & V. Malini , Operations Research, Margham Publications, 2016.
4. Kanti Swarup, P.K. Gupta, Man Mohan, Operations Research, 19th edition, Sultan Chand & Sons, 2020.

JOURNALS

The Mathematics Intelligencer .

Mathematics News letter.

WEBSITES AND E-LEARNING SOURCES

1. https://nptel.ac.in/courses/111/105/111105039/
2. https://nptel.ac.in/courses/112/106/112106134/
3. https://nptel.ac.in/courses/111/107/111107128/

COURSE OUTCOMES: Upon Completion of this course, the students will be able to

CO NO.	CO Statement
CO 1	Identify problems with fundamentals of LPP
CO 2	Create and solve problems by various techniques
CO 3	Use the applications in transportation problem.
CO 4	Apply PERT techniques to plan, schedule and control project activities.
CO 5	Select various concepts in sequencing problems

Mapping of CO with PSO

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	**2**	**3**	**2**	**3**	**2**
CO2	**2**	**2**	**3**	**2**	**2**
CO3	**3**	**2**	**2**	**3**	**2**
CO4	**3**	**3**	**2**	**3**	**2**
CO5	**2**	**2**	**3**	**2**	**2**
Average	**2**	**2.2**	**2.3**	**2.4**	**2.2**

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

TEACHING METHODOLOGY:

Lecture (chalk and talk), Problem Solving,Discussion and Interactive session, Assignment, Quiz, Seminar.

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

ANALYTICAL SKILLS FOR NET/SET

Soft Skill: 3 **Course Code: 11SP21/3S/ASN**

Teaching Hours: 30 Hrs **Credits: 2 L T P: 2 0 0**

COURSE OBJECTIVES:

To enable the students to

1. To be familiar with the pattern of various examinations
2. Get the information about the exams conducted for research and entry into jobs
3. Use time effectively and become aware about the various analytical skills

COURSE OUTLINE:

UNIT I: Analysis

Sequences and Series-Continuity-Differentiability- Cauchy-Riemann Equations- Singularities-Residues **(10 hrs)**

UNIT II: Algebra

Groups-Cyclic Groups-Class Equations – Sylow Theorems-Rings -Fields **(10 hrs)**

UNIT III: Differential Equations

First Order Ordinary Differential Equations-First Order Partial Differential Equations- Heat Equations-Wave Equations **(10 hrs)**

RECOMMENDED TEXTS

1. N. P. Bali ,Golden Real Analysis , Laxmi Publications, 2019.
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 2nd Edition, 2012.
3. S. Arumugam, A. Thangapandi Isaac & A. Somasundaram, Complex Analysis, SciTech publications (India) Pvt., Ltd., 2016.
4. M. D. Raisinghania, Advanced Differential Equations, S. Chand Ltd.,19th Edition, 2018.

REFERENCE BOOKS:

1. Robert G. Bartle, Introduction to Real Analysis John Wiley & Sons, 4th Edition, 2011.
2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2nd Edition, 2011.
3. Joseph. A. Gallian , Contemporary Abstract Algebra, Published by Chapman and Hall/CRC Press, Taylor & Francis Group, 2020.
4. Shepley Ross, Differential Equations, John Wiley & Sons, 3rd Edition, 2018.
5. Tom Apostol, Introduction to Analytic Number Theory, Springer New York, 2013.

Journals:

Journal of Algebra and its Applications
Complex Analysis and Operator Theory
Journal of Differential equations
International Journal of Differential equations
The Mathematics Intelligencer
Mathematic News Letter

Websites and e- learning sources:

1. http//mathforum.org
2. http//www.opensource.org
3. http//www.khanacademy.org
4. http//in.ixl.com
5. http//www.learningwave.org

COURSE OUTCOMES : Upon Completion of this course ,the students will be able to

CO No.	CO STATEMENT
CO 1	Apply Principles of Mathematics
CO 2	Demonstrate the understanding of the algebraic concepts
CO 3	Prepare to classify the Differential Equations with respect to their order and linearity and solve problems with initial and boundary conditions

MAPPING : Course Outcome with Programme Specific Outcome

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	1	3
CO2	2	3	3	1	3
CO3	2	2	3	1	3
Average	2.3	2.3	3	1	3

Key: Strongly Correlated-3, Moderately Correlated-2, Weakly Correlated-1

No correlation-0

Teaching Methodology: Lecture (chalk and talk, LCD projector), Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar.

Template – End Semester Examination

Knowledge Level	Section	Marks	Total
K_1, K_3, K_5	A (50x 1 = 50 marks)	50	50

SEMESTER – III

SELF – STUDY (OPTIONAL)

SPECIAL FUNCTIONS

Course Code: 11SP21/3SS/SPF **Credits: 2**

Learning Objectives: To enable students to

1. Understand concepts of differential equations
2. Introduce Laplace's equation and its integral.
3. Analyze and understand theorems on Legendre function and Bessel function.
4. Apply the Legendre equation in mathematical science.

COURSE OUTLINE:

Unit I : Legendre Polynomials and Functions

Legendre's equation and its solution – Legendre's function of the first kind or Legendre's polynomial of degree n – Generating function for Legendre polynomials – Solved examples – Trigonometric series for $P_n(x)$ – Laplace's definite integrals for $P_n(x)$ – Some bounds on $P_n(x)$.

Chapter 9 : Sections 9.1 – 9.7

Unit II :Legendre Polynomials and Functions(Contd..)

Orthogonal properties of Legendre's polynomials – Recurrence relations (formulae) – Beltrami's result – Christoffel's summation formula- Christoffel's expansion – Solved examples – Rodigue's formula. .

Chapter 9 : Sections 9.8 – 9.14

Unit III : Legendre functions of second kind

Some useful results - Recurrence Relation – Theorem – Complete solution of Legendre's equation – Christoffel's second summation formula – A relation connecting $P_n(x)$ and $Q_n(x)$ – Neumann's integral for $Q_n(y)$ – Solved examples.

Chapter 10 : Sections 10.1 -10.8

Unit IV : Bessel functions

Bessel's equation and its solution – Bessel's function of the first kind of order n – Results of Gamma and Beta functions – Relation between $J_n(x)$ and $J_{-n}(x)$, n being an integer – Bessel's function of the second kind of order n – Integration of Bessel equation in series for n = 0 – Bessel's function of zeroth order – Solved Examples – Recurrence Relation for $J_n(x)$ – Solved examples – examples involving integration and recurrence relation.

Chapter 11: Sections 11.1 -11.7

Unit V : Bessel functions (Contd..)

Generating function for the Bessel's function $J_n(x)$ – Trigonometric expansions involving Bessel's functions – Solved examples – Orthogonality of Bessel's function – Bessel's series or Fourier – Bessel's expansion for f(x) – Solved examples .

Chapter 11: Sections 11.8 - 11. 11

RECOMMENDED TEXT BOOK:

Advanced Differential Equations , M.D. Raisinghania, 2019, 19th edition, S.Chand and Company Ltd.

REFERENCE BOOKS:

1. Differential Equations with applications and Historical Notes, George .F. Simmons.3rd edition, CRC Press.
2. Differential Equations by Ganesh C.Gorian, Narosa Publishing House.
3. Special Functions, Earl. D. Ranvillie, Macmillan, 1960.
4. Special Functions of Mathematics for Engineers, L.C. Andrews , 2nd Edition, SPIE Press, 1992.
5. Special functions, An Introduction to the Classical Functions of Mathematical Physics, John Wiley ,Sons Inc, New york, 1996.

PERIODICALS:

1. The Mathematics Intelligencer.
2. Mathematics Newsletters.

Websites & e - Learning Sources:

1. https://en.wikipedia.org/wiki/Legendre_polynomials
2. https://nptel.ac.in/content/storage2/courses/122104018/node86.html
3. https://mathworld.wolfram.com/BesselFunctionoftheFirstKind.html
4. http://nptelvideos.com/video.php?id=64
5. https://unacademy.com/lesson/orthogonality-of-bessel-function/BU30BA9Y

COURSE OUTCOME :

Upon successful completion of Special Functions, Students will be able to

CO Number	CO Statement
CO 1	Analyze the concept of Legendre polynomial and its function.
CO 2	Assess the orthogonal properties of Legendre polynomial.
CO 3	Understands the results of Christoffel's second summation formula and Newmann's integral .
CO 4	Use the concepts of Bessel's function and Bessel equation.
CO 5	Applies Bessel's equation and Bessel's function to solve mathematical problems.

MAPPING : Course Outcome With Programme Specific Outcome

CO /PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	2	3	3	1	3
CO 2	3	3	3	1	2
CO 3	3	3	3	1	2
CO 4	3	3	3	1	2
CO 5	3	3	3	1	2
Average	**2.8**	**3**	**3**	**1**	**2.2**

Key : Strongly Corelated-3 **M**oderately Corelated-2 **W**eakly Corelated-1
No Corelation-0

Template–End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

SELF – STUDY (OPTIONAL)
INTRODUCTION TO MACHINE LEARNING

Course Code: 11SP21/3SS/MAL **Credits: 2**

COURSE OBJECTIVES:

Enable the students to

1. Provide an overview of Machine Learning.
2. Prepare and evaluate a model.
3. Provide feature engineering concepts.
4. Introduce supervised learning concepts and algorithms.
5. Introduce unsupervised learning concepts and algorithms.

COURSE OUTLINE:

UNIT I:

Introduction to Machine Learning: What is machine learning? – Types of machine learning – Applications of machine learning – Issues in machine learning. Preparing to Model: Machine Learning Activities- Types of Data – Data quality and remediation.

UNIT II:

Modelling and Evaluation: Selecting a Model – Training a Model – Model representation and Interpretability - Model Performance and evaluation - Improving performance of a model.

UNIT III:

Basics of Feature Engineering: Introduction – Feature Transformation – Feature subset selection.

UNIT IV:

Supervised Learning (Classification): Introduction – Example – Classification model – Classification learning steps – Common classification algorithms. Supervised Learning (Regression): Introduction – Example – Common regression algorithms.

UNIT V:

Unsupervised Learning: Introduction – Unsupervised Vs Supervised learning – Applications – Clustering – finding pattern using Association rule.

RECOMMENDED TEXTS:

Machine Learning by Saikat Dutt, Subramanian Chandramouli, Amit Kumar Dass Pearson India Education, 2019.

REFERENCE BOOKS:

1. Machine Learning For Absolute Beginners: A Plain English Introduction by Oliver Theobald, Scatterplot Press,2017.
2. The Hundred-Page Machine Learning Book by Andriy Burkov, Genre:Computers, 2019.

E-Learning Resources:

S.No	URL
1	https://www.edureka.co/blog/machine-learning-tutorial/
2	https://www.toptal.com/machine-learning/machine-learning-theory-an-introductory-primer
3	https://www.coursera.org › learn › machine-learning
4	https://www.geeksforgeeks.org/machine-learning/

COURSE OUTCOME: Upon successful completion of Students will be able to

CO Number	CO statement
CO 1	Explain the different concepts in machine learning.
CO 2	Design and evaluate a model.
CO 3	Provide feature concepts in engineering.
CO 4	Learning supervised concepts and algorithms.
CO 5	Explain the unsupervised concepts and algorithms.

MAPPING - Course Outcome With Programme Specific Outcome

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	2	2	2	3	2
CO 2	2	2	2	2	2
CO 3	2	2	2	3	2
CO 4	2	2	2	3	2
CO 5	2	2	2	3	2
Average	2	2	2	2.8	2

Key : Strongly Corelated-3, **M**oderately Corelated-2, **W**eakly Corelated-1, **N**o corelation-0.

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

SEMESTER IV COURSE PROFILE

Course Title & Course Code	Credits	Hours/week	Total Hours	L	T	P	C.A	S.E	Total	Page No
Complex Analysis -II 11SP21/4C/CA2	4	6	90	3	3	0	40	60	100	**79**
Functional Analysis 11SP21/4C/FAN	4	6	90	3	3	0	40	60	100	**82**
Numerical Python 11SP21/4C/NPY	4	6	90	2	2	2	40	60	100	**85**
Calculus of Variations and Integral equations 11SP21/4C/CVI	4	5	75	3	2	0	40	60	100	**89**
Project 11SP21/4C/PRO	3	5	75				-	-	100	**92**
LATEX- A Document Preparation System (Soft Skills) 11SP21/4S/LAT	2	2	30	0	0	2	-	-	50	**93**

SEMESTER – IV

COMPLEX ANALYSIS – II

Core: 12 **Course Code: 11SP21/4C/CA2**

Teaching Hours: 90 Hrs **Credits:4** **L T P: 3 3 0**

Course Objectives:

To enable the students to

1. Have the foundation on topics in Advanced Complex Analysis
2. Develop clear thinking and analyzing capacity for research
3. Introduce Riemann Zeta function
4. Impart knowledge on normal families and family of analytic functions
5. Be familiar with Elliptic functions

COURSE OUTLINE:

UNIT I: The Riemann Zeta Function

The Product Development-Extension of $\zeta(s)$to the Whole Plane- The Functional Equation - The Zeros of the Zeta Function.

Chapter 5 : Section 4: 4.1- 4.4 **(15 hrs)**

UNIT II: Normal Families

Equicontinuity - Normality and Compactness - Arzela's Theorem-Families of Analytic Functions - The Classical Definition.

Chapter 5 : Section 5: 5.1 - 5.5 **(20 hrs)**

UNIT III: Conformal Mapping

The Riemann Mapping Theorem: Statement and Proof- Boundary Behavior-Use of the Reflection Principle, Conformal Mapping of Polygons: The Behavior at an Angle – The Schwarz - Christoffel Formula – Mapping on a Rectangle.

Chapter 6 : Section 1: 1.1 - 1.3, Section 2: 2.1 - 2.3 **(15 hrs)**

UNIT IV: Elliptic functions

A Closer Look at Harmonic Functions: Functions with the Mean Value Property- Harnack's Principle, Simply Periodic Functions: Representation by Exponentials - The Fourier Development-Functions of Finite Order.

Doubly Periodic Functions: The Period Module-Unimodular Transformations.

Chapter 6: Section 3: 3.1, 3.2, Chapter 7: Section 1: 1.1 to 1.3, Section 2 : 2.1, 2.2 **(20 hrs)**

UNIT V: The Weierstrass Theory

Doubly Periodic Functions: The Canonical Basis-General Properties of Elliptic Functions– The Weierstrass ρ- function-The Functions $\zeta(z)$ and $\sigma(z)$- The Differential Equation –The Modular Function $\lambda(\tau)$.

Chapter 7: Section 2: 2.3 and 2.4, Section 3: 3.1 - 3.4 (20 hrs)

RECOMMENDED TEXTS:

Lars.V. Ahlfors, Complex Analysis (3rd Edition) Mc Graw Hill Co., New York, 2017.

REFERENCE BOOKS:

1. H.A. Priestley, Introduction of Complex Analysis, OUP Oxford publisher, 2nd Edition, 2003.
2. J. B. Conway, Functions of one complex variable I, Springer publisher, 2nd Edition, 1978.
3. E. Hille, Analytic function theory (2 Vols.), published by Cambridge University Press, 2nd Edition, 2016.
4. M. Heins, Complex function theory, Academic Press New york, 1968.
5. Tom Apostol, Introduction to Analytic Number Theory, Springer New York, 2013.

Journals:

Complex Analysis and its synergies
Complex Analysis and Operator Theory
Complex Manifolds
The Mathematics Intelligencer
Mathematic News Letter

Websites and e- learning sources

1. http//www.opensource.org
2. http//www.mathworld.wolfram.com
3. http//www.iitg.ac.in
4. http//www.maths.leeds.ac.uk
5. http//www.maths.tcd.ie

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

CO Number	Co Statement
CO 1	describe the connection between prime distribution and Zeta function
CO 2	Analyze about family of functions defined in complex Domain.
CO 3	Discuss mapping properties of elementary functions and some special functions
CO 4	Recognize simple periodic and doubly periodic functions
CO 5	Identify the functions which have either a double pole with zero residue or two simple poles with equal residues but opposite in signs

MAPPING - Course Outcome with Programme Specific Outcome

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	1	2	1	1	1
CO 2	2	2	2	1	2
CO 3	2	2	1	1	1
CO 4	2	2	1	1	2
CO 5	2	1	1	1	1
Average	**1.8**	**1.8**	**1.2**	**1**	**1.4**

Key : **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (chalk and talk, LCD projector),Problem Solving, Discussion and Interactive session, Assignment, Quiz, Seminar.

Template – End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems- Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

FUNCTIONAL ANALYSIS

Core - 13 **Course Code : 11SP21/4C/FAN**

Teaching hours: 90 **Credits: 4** **L T P : 3 3 0**

Course Objectives: This course will enable the students

1. To understand the hard core of Functional Analysis.
2. To have a clear picture about Banach spaces and theorems related to it.
3. To know the ideas of Complex Banach spaces.
4. To realize deeply about Hilbert spaces and its properties.
5. To explore and study about the nature and properties of Banach Algebra.

COURSE OUTLINE:

UNIT I: Banach Spaces

The definition and some examples - Continuous linear transformations, The Hahn – Banach theorem.

Chapter: 9 Section : 46 - 48 **(20 hours)**

UNIT II: Banach Spaces (Contd..)

The natural imbedding of N in N**- The open mapping theorem - The conjugate of an operator.

Chapter: 9 Section: 49 - 51 **(15 hours)**

UNIT III: Hilbert Spaces

The definition and some simple properties - Orthogonal complements – Orthonormal sets - The Conjugate space H*.

Chapter: 9 Section: 52 - 55 **(20 hours)**

UNIT IV: Hilbert Spaces (Contd..)

The adjoint of an operator - Self – adjoint operators - Normal and unitary operators – Projections

Chapter: 10 Section: 56 - 59 **(20 hours)**

UNIT V: Banach Algebra

Banach algebra Definition and some examples – Regular and singular elements – topological divisors of zero – The spectrum - The formula for the spectral radius.

Chapter :12 Sections : 64 - 68 **(15 hours)**

RECOMMENDED TEXT:

G.F. Simmons, Introduction to Topology and Modern Analysis, McGrawHill International Book Company, NewYork, 2004.

REFERENCE BOOKS :

1. W. Rudin, Functional Analysis, 2nd edition, Tata McGraw-Hill Education (India) Pvt. Ltd., New Delhi, 2006.
2. S. Ponnusamy, Foundations of Functional Analysis I st edition, Narosa Publishing House Ltd, New Delhi 2011.
3. H. C. Goffman and Pedrick, First course in Functional Analysis, Prentice Hall of India, New Delhi, 2002.
4. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, NewYork, 2014.
5. BalmohanVishnu Limaye, Functional Analysis, Second edition, New Age International(P) Limited, 2004.

Journals

Journal of Functional Analysis-Elsevier
Journal of Functional Analysis and Applications – Springer
Mathematics News letter.

Websites and E-Learning Sources:

1. http://math-forum.org
2. https://www.sciencedirect.com/journal/journal-of-functional-analysis
3. http://ocw.mit.edu/ocw web/Mathematics,
4. http://www.opensource.org,
5. https://nptel.ac.in /courses/111105037/31
6. https://www.elsevier.com/mathematics

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

CO No.	CO Statement
CO 1	Identify Banach spaces and analyse their properties with other types of spaces.
CO 2	Examine and identify properties of complex Banach spaces- Hilbert spaces.
CO 3	Apply the analytical techniques and theoretical knowledge in Hilbert Spaces. Find out and determine orthonormal sets.
CO 4	Explain various properties of Hilbert spaces.
CO 5	Gain knowledge and experience of working with many pure mathematical problems.

MAPPING - Course Outcome With Programme Specific Outcome

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2
CO2	3	2	2	2	2
CO3	3	2	2	2	2
CO4	3	2	2	2	2
CO5	3	2	2	2	2
Average	**3**	**2**	**2.2**	**2.2**	**2**

Key : **S**trongly Correlated-3,**M**oderately Correlated-2,**W**eakly Correlated-1
No correlation-0

Template–End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

NUMERICAL PYTHON

Core -14 **Course Code: 11SP21/4C/NPY**

Teaching hours: 90 **Credits: 4** **L T P : 2 2 2**

Course Objectives:

This course will enable the students to

1. Learn the basic principles of Python programming language.
2. Create and manipulate arrays by using NumPy.
3. Use the plotting functions of matplotlib and to present the results graphically.
4. Learn to conduct statistical analysis and visualization of data.
5. To get knowledge on fundamental elements of Machine Learning.

COURSE OUTLINE:

UNIT I

Basics of Python Programming-Function: Function definition-Function call- The Return Statement- More on defining functions- Lambda functions – Recursive Functions. Strings: Introduction- Concatenating, appending, and multiplying strings- String formatting operator- Built- in String methods and functions – Slice operation- in and not in operators- comparing strings, Lists:Access values in lists- Updating values in lists- Nested lists – Cloning lists- Basic list operations, Tuple: Creating tuple – Utility of tuples - Accessing values in a tuple- Updating Tuple – Deleting elements in tuple- Basic tuple operations, Dictionaries: Creating a dictionary- Accessing values- Adding and modifying an item in a dictionary- Modifying an entry- Deleting items- Sorting items in a dictionary- Looping over a dictionary-Nested dictionaries.

Book 1: Chapter 3: Section 3.1 – 3.13,
Chapter 5: Section 5.1 -5.3, 5.5- 5.7, 5.10
Chapter 6: Section 6.1 – 6.5, 6.7, 6.8
Chapter 8: Section 8.2(8.2.1 – 8.2.6), Section 8.4 (8.4.1 – 8.4.6)
Section 8.6 (8.6.1 – 8.6.7) **(20 hrs)**

UNIT II

Vectors, Matrices and Multidimensional arrays - Importing the modules-The NumPy Array Object - Creating arrays-Indexing and Slicing - One-dimensional arrays Multi Dimensional arrays - Fancy indexing and Boolean -Valued indexing - Reshaping and Resizing - Vectorized expressions - Matrix and vector operations

Book 2: Chapter 2. **(15 hrs)**

UNIT III

Plotting and visualization-importing modules-Interactive and non interactive Modes - Figure- Axes - Colormap plots. Equation solving - Importing modules - Linear equation systems - Eigen value problems.

Book 2: Chapter 4 (omit section 3D plots) (15 hrs)
Chapter 5 (omit section Nonlinear equations)

UNIT IV

Data processing and analysis - Importing modules - Introduction to Pandas - Time series. Statistics - Importing modules - Review of statistics and probability - Random numbers – Random variables and distributions-Hypothesis testing. Statistical modeling - Importing modules - Introduction to statistical modeling - Defining statistical models with Patsy-Linear regression.

Book 2: Chapter 12 (omit section Seaborne graphics library) (20 hrs)
Chapter 13 (omit section Nonparametric methods)
Chapter 14 (omit sections Discrete regressions, Time series)

UNIT V

Machine learning-Importing modules-Brief review of machine learning-Regression-Clustering. Bayesian Statistics-Importing Modules-Linear Regression

Book 2: Chapter 15 and Chapter 16.

(20 hrs)

RECOMMENDED TEXT :

1. Reema Thareja, ``Python programming using problem solving approach'', 10th impression 2021, Oxford University press, New Delhi.
2. Robert Johansson , ``Numerical Python Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib" Second Edition A.Press2018.

REFERENCE BOOKS:

1. Hans Petter Langtangen and Svein Linge, Programming for Computations - Python: A Gentle introduction to Numerical Simulations with Python. Springer, 2016.
2. Jaan Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press, 2013,
3. Andreas C. Müller and Guido, Introduction to Machine Learning with Python", O'reilly media, 1st Edition, 2016

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PERIODICALS:

` International journal of computer science

WEBSITES AND e - LEARNING SOURCES

1. https://nptel.ac.in/courses/106/106/106106212/
2. https://www.pythonprogramming.in/numpy-tutorial-with-examples-and-solutions.html
3. https://greenteapress.com/wp/think-python/
4. https://w3resource.com/python-exercises/

COURSE OUTCOME: Upon successful l completion of Students will be able to:

CO Number	CO statement
CO 1	Explain basic principles of Python programming language.
CO 2	Know operations available in NumPy.
CO 3	Create and interpret data visualizations using the Python programming language.
CO 4	Understand importance of statistical modeling.
CO 5	Develop knowledge on Machine learning.

MAPPING - Course Outcome With Programme Specific Outcome

CO / PSO	PSO 1	PSO 2	PSO3	PS04	PSO5
CO1	2	2	2	3	2
CO2	2	2	2	2	2
CO3	2	2	2	3	2
CO4	2	2	2	3	2
CO5	2	2	2	3	2
Average	2	2	2	2.8	2

Key: Strongly Corelated-3 **M**oderately Corelated-2 **W**eakly Corelated-1 **N**ocorelation-0

TEACHING METHODOLOGY:

Lecture (Chalk and Talk- OHP - LCD), Group Discussion, Quiz-Seminar, Peer Learning

Template–End Semester Examination

Knowledge level	**Section**	**Nature of the question**	**Maximum Marks**	
K_3	A	Understanding Description/Problems Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

EVALUATION PATTERN FOR CONTINUOUS ASSESSMENT

Internal Valuation by Course Teacher/s

Component	**Time**	**Max. Marks**	**CA mark**
Test I	2 hours	50 marks (to be converted to10)	10
Test II	2 hours	50 marks (to be converted to10)	10
Practical exam	2 hours	50 marks (to be converted to20)	20

ASSESSMENT OF COMPUTER PRACTICAL EXAMINATION

Two out of three questions will be asked for the practical examination.

For each question

Programming skill (writing) - 10 marks

Technical Skill (Keying) - 10 marks

Debugging and generating output - 5 marks.

CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

Core - 15 **Course Code: 11SP21/4C/CVI**

Teaching Hours: 75 **Credits:4** **LT P : 3 2 0**

COURSE OBJECTIVES:

To enable the students to

1. understand the basic techniques and results of the Calculus of Variations and Integral Equations.
2. acquire knowledge about the integral equation, its classification ,different kinds of kernels.
3. know about successive approximations, resolvent kernel of a integral equation,
4. formulate important results and theorems
5. use the theory, methods and techniques of integral equations to solve problems;

COURSE OUTLINE:

UNIT I: The Method of Variations in Problems with Fixed Boundaries

Variation and its properties – Euler's Equation – Functionals of the form $\int_{x_0}^{x_1} F\left(x, y_1, y_2, \ldots\ y_n, y_1^{'}, y_2^{'}, \ldots, y_n^{'}\right)dx$ - Functionals Dependent on Higher – Order Derivatives.

Chapter 6: 6.1 – 6.4 **(10 hrs)**

UNIT II: Variational Problems with Moving Boundaries and certain other Problems

An Elementary Problem with moving Boundaries- The moving Boundary Problem for a Functional of the form $\int_{x_0}^{x_1} F(x, y, y^{'}, x')dx$. -

Sufficient Conditions for an Extremum

Field of Extremals - The function E(x, y, p, y')

Chapter 7:7.1,7.2

Chapter 8: 8.1 8.2 **(15 hrs)**

UNIT III: Integral Equations – Seperable Kernels

Introduction – Definition– Regularity Conditions -Special kinds of Kernels Eigen values and Eigen functions – Convolution Integral – The Inner or Scalar Product of Two Functions - Reduction to a System of Algebraic Equations – Examples – Fredholm Alternatives – Examples- An Approximate Method .

Chapter 1: 1.1 to 1.7 & Chapter 2: 2.1to 2.5 **(15 hrs)**

UNIT IV: Method Of Successive Approximations - Classical Fredholm Theory

Iterative Scheme – Examples – Volterra Integral Equation – Examples – Some Results about the Resolvent Kernel – The Method of Solution of Fredholm – Fredholm's First theorem(Statement only) – Examples- Fredholm's Second & Third theorem (Statement only)

Chapter 3: 3.1 to 3.5 & Chapter 4 : 4.1 to 4.5 (20 hrs)

UNIT V: Applications To Ordinary Differential Equations

Introduction – Fundamental Properties of Eigen values and Eigen functions for Symmetric Kernels- Expansion in Eigen functions and Bilinear Form – Hilbert - Schmidt Theorem (Statement only) - Solution of a Symmetric Integral Equation - Examples - Abel Integral Equation - Examples.

Chapter 7 : 7.1 to 7.6

Chapter 8 : 8.1, 8.2 (15 hrs)

RECOMMENDED TEXT

1. L. Elsgolts, Differential Equations and the Calculus of Variations, University Press of the Pacific, Honolulu, Hawaii, 2004.(for Unit I, Unit II).
2. Ram P. Kanwal, Linear Integral Equations, Theory and Techniques, Second Edition , Academic Press, New York, 1997. (for Units III, IV and V)

REFERENCE BOOKS

1. A. S. Gupta, Calculus of Variations with Applications, PHI Learning Private Ltd, New Delhi, 2005.
2. M. D. Raisinghania, Integral Equations and Boundary Value Problems, S. Chand & Co., New Delhi,9th edition, 2016.
3. Israel M.Gelfand and S.V.Fomin, Calculus of Variations,1991,Dover Publications.
4. A First Course in Integral Equations, Abdul Majid Wazwaz, Second edition.
5. Calculus of Variations, A.R.Forsyth ,Cambridge, the University Press, 1927, Edition 2011.

COURSE OUTCOMES : Upon Completion of this course, the students will be able to

Co No.	Course Outcome Statement
CO 1	Apply Euler-Lagrange equation or its first integral to find differential equations for stationary paths. Demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces
CO 2	Find the extremal of a functional.
CO3	Acquire sound knowledge of different types of Integral equations: Fredholm and Volterra integral equations. Represent integral equations to algebraic system of equations
CO4	Evaluates the solution to an integral equation using successive approximation.
CO5	Finds solution to a symmetric integral equation.

Periodicals:

The Mathematics Intelligencer.
Mathematics News letter.
www.researchgate.net/journal/1864-8258

Websites and e-Learning Sources:

1. https://nptel.ac.in/courses/111/107/111107103/
2. https://www.digimat.in/nptel/courses/video/111104025/L01.html
3. https://encyclopediaofmath.org/wiki/Jacobi_condition
4. https://nptel.ac.in/noc/courses/noc17/SEM2/noc17-ma12/

MAPPING – Course Outcome With Programme Specific Outcome

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	3
CO2	2	2	2	1	2
CO3	3	2	3	1	3
CO4	3	3	3	1	3
CO5	3	3	2	1	2
Average	2.8	2.6	2.6	1	2.6

Key: **S**trongly Correlated-3, **M**oderately Correlated-2, **W**eakly Correlated-1
No correlation-0

Teaching Methodology: Lecture (Chalk and Talk LCD) Problem Solving, Seminar, Peer Learning

Template – End Semester Examination

Knowledge level	Section	Nature of the question	Maximum Marks	
K_3	A	Understanding Description/Problems-Two questions from every Unit	10 x 2	20
K_4, K_5	B	Analysis, Evaluation, Description/Problems-At least one question from every Unit	5 (out of 8) x 7	35
K_4, K_5	C	Application/ Analysis/ Synthesis/ Evaluation –One question from every Unit	3 (out of 5) x 15	45
			Total	100
Note: At least two questions from Section A and one question from Section B should be taken to test problem solving skills.				

PROJECT

Course Code: 11SP21/4C/PRO **Credits: 3**

Duration: 75 hours

Project based learning has been designed to create opportunities for students to explore, gather information and think critically.

Project based learning is a learner- centered instructional method which supports learning through engaging students in an investigation of a topic worth learning more about. Students can reap many benefits from project based learning strategy in terms of influencing goal orientation, increasing curiosity to search, augmenting engagement, promoting mastery of new knowledge, fostering problem-solving skills, developing critical thinking, enhancing peer learning and improving communication skills.

The student can select their topics from various fields of Mathematics .This project development idea will give an exposure to the student to identify the various applications of Mathematics.

The report should include

- Title Page
- Abstract Body
- Introduction Theory
- Analysis, Results & Discussion
- Conclusions
- References
- Appendices (if applicable).

The duration of the course is 75 (15 x 5) hours .

The report shall consist of minimum of 50 printed pages.

Valuation is both by Internal and External examiners.

Project: 60 marks.

Viva – Voce: 40 marks.

LATEX - A DOCUMENT PREPARATION SYSTEM

Soft Skill: 4 **Course Code: 11SP21/4S/LAT**

Total Hours: 30 **Credits: 2 L T P: 0 0 2**

Course Objectives:

To enable the students

1. To introduce the basic concepts of Latex, a type setting software
2. To get knowledge about creating a bibliographic database.
3. To impart knowledge on New operators, Symbols, Footnotes, Marginpars and Endnotes in Mathematics.

COURSE OUTLINE:

UNIT I

The Basics-Document class – Page style – Page numbering –Formatting lengths –Parts of a document–Dividing the document–Bibliography. **(10 hrs)**

UNIT II

The BIBTEX program – BIBTEX style files–Creating a bibliographic database-Table of contents, Index and Glossary**,** Keeping tabs - Tables. Floats-Cross References In Latex. **(10 hrs)**

UNIT III

Typesetting Mathematics- The basics - Custom commands - More on Mathematics – New operators–Symbols-Theorems in LATEX–Designer theorems, Several kinds of boxes. Foot notes, Margin pars and End notes. **(10 hrs)**

REFERENCE BOOKS:

1. LATEX: A document preparation system (2nd edition), Leslie Lamport.
2. A beginner's introduction to typesetting with LATEX, Peter Flynn, 2003.

Websites and E-Learning Sources:

https://www.overleaf.com/learn/latex/Tutorials

https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf

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

CO Number	CO statement
CO 1	Create Page numbering , Formatting lengths Dividing the document and Bibliography using Latex.
CO 2	Create a bibliographic database, Table of contents, Index and Glossary**.**
CO 3	Design New operators, Symbols, Footnotes and End notes in Mathematics and apply these ideas in writing journals and books.

MAPPING – Course Outcome With programme specific outcome

CO/PSO	PSO1	PSO2	PSO3	PS04	PSO5
CO1	2	1	1	3	2
CO2	2	2	1	2	1
CO3	1	2	1	3	2
Average	**1.6**	**1.6**	**1.0**	**2.6**	**1.6**

Key : **S**trongly Correlated-3,**M**oderately Correlated-2,**W**eakly Correlated-1
No correlation-0

Teaching Methodology : Lecture (chalk and talk, LCD projector),Problem Solving, Discussion and Interactive session,

QUESTION PAPER PATTERN

Duration – 2 hours**.**

Practical examination will be conducted for 50 marks (Internal valuation).

Five (Out of seven) questions, each carrying 10 marks.