ARULMIGU PALANIANDAVAR ARTS COLLEGE FOR WOMEN,

PALANI.

(Autonomous)

(Re-accredited With B++grade by NAAC in 3rd Cycle)

M.Sc., MATHEMATICS

TANSCHE SYLLABUS TO BE IMPLEMENTED FROM THE ACADEMIC YEAR 2023-2024

(CHOICE BASED CREDIT SYSTEM)

PG DEPARTMENT OF MATHEMATICS
M.SC. MATHEMATICS
SYLLABUS
2023-2024 ONWARDS

ARULMIGU PALANIANDAVAR ARTS COLLEGE FOR WOMEN
(Affiliated to Mother Teresa Women's University, Kodaikanal)
Nationally Reaccredited with B^{++} Grade by NAACin 3rd Cycle
Chinnakalayamputhur, Palani - 624 615.

PG DEPARTMENT OF MATHEMATICS

Choice Based Credit System (CBCS)

(2023-2024 onwards)

M.SC. MATHEMATICS

Preamble:

The main aim of the Programme is intended to provide in-depth knowledge to the students in advanced Pure and Applied mathematics and prepare them for various research activities and career opportunities. The Programme is designed to impart proficiency in Mathematical application in day-to-day in simple and complex situations. The Programme also will enable the learners to shine as collaborators and innovators in addressing social, technical, and business challenges. Programme through its wide range of Courses trains the students as competent citizens with advanced mathematical knowledge and ethically sound humans with its insistence of human ethics. The Programme is intended to promote the culture of interdisciplinary studies and research that is much needed for the current scenario.

Program Educational Objectives (PEOs)	
The **M. Sc. Mathematics** program describe accomplishments that graduates are expected to attain within five to seven years after graduation	
PEO1	Provide a strong foundation in different areas of Mathematics, so that the students can compete with their contemporaries and excel in the various careers in Mathematics.
PEO2	Motivate and prepare the students to pursue higher studies and research, thus contributing to the ever-increasing academic demands of the country.
PEO3	Enrich the students with strong communication and interpersonal skills, broad knowledge and an understanding of multicultural and global perspectives, to work effectively in multidisciplinary teams, both as leaders and team members.
PEO4	Facilitate integral development of the personality of the student to deal with ethical and professional issues, and also to develop ability for independent and lifelong learning.
PEO5	improvise the women resource that is furnished with the mathematical skills that are necessary in the altering industrial and socio-economic development of the,country

Program Specific Outcomes (PSOs)	
After the successful completion of **M. Sc. Mathematics** program, the students are expected to	
PSO1	Communicate concepts of Mathematics and its applications.
PSO2	Acquire analytical and logical thinking through various mathematical tools and techniques.
PSO3	Investigate real life problems and learn to solve them through formulating mathematical models.
PSO4	Attain in-depth knowledge to pursue higher studies and ability to conduct research. Work as mathematical professional
PSO5	Achieve targets of successfully clearing various examinations/interviews for placements in teaching, banks, industries and various other organizations/services.

Program Outcomes (POs)	
On successful completion of the M. Sc. Mathematics program, the students will be able to	
PO1	Demonstrate in-depth knowledge of Mathematics, both in theory and application.
PO2	Attain the ability to identify, formulate and solve challenging problems in Mathematics.
PO3	Know the various specialised areas of advanced mathematics and its applications.
PO4	Analyze complex problems in Mathematics and propose solutions using research-based knowledge.
PO5	Obtain the accurate solutions for the community oriented problems via various mathematical models.
PO6	Work individually or as a team member or leader in uniform and multidisciplinary settings.
PO7	Crack lectureship and fellowship exams affirmed by UGC like CSIR-NET and SET.
PO8	Apply the Mathematical concepts, in all the fields of learning including higher research, and recognize the need and prepare for lifelong learning.
PO9	Know the use of computers both as an aid and as a tool to study problems in Mathematics.
PO10	Inculcate the knowledge of formulation and apply the mathematical concepts which are suitable for real life applications.

1. **Eligibility :B.Sc. Mathematics**
2. **General Guidelines for PG Programme**

i. **Duration:** The programme shall extend through a period of 4 consecutive semesters and the duration of a semester shall normally be 90 days or 450 hours. Examinations shall be conducted at the end of each semester for the respective subjects.

ii. **Medium of Instruction:** English

iii. **Evaluation:** Evaluation of the candidates shall be through Internal Assessment and External Examination.

- **Evaluation Pattern**

Evaluation Pattern	Theory& Practical	
	Min	Max
Internal	13	25
External	38	75

- **Internal (Theory): Test (15) + Assignment (5) + Seminar/Quiz(5) =25**
- **External Theory:75**

Components of Continuous Internal Assessment

Components		Marks	Total
Theory			
CIA I	30	(30+30 = 60/4) 15	25
CIA II	30		
Assignment		5	
Seminar/Quiz		5	

- **Question Paper Pattern for Internal examination for all core and Elective papers.**

Max.Marks:25 **Time: 2Hrs.**

S.No.	Part	Type	Marks
1	**A**	**3*2 Marks=6** Q.No.1 to 3	**6**
2	**B**	**2*4 Marks=8** (Either or Pattern) Q.No. 4 and 5	**8**
3	**C**	**2*8 Marks=16** (Either or Pattern) Q.No. 6 and 7	**16**
Total Marks			**30**

- **Question Paper Pattern for External examination for all course papers.(except** Elective-VI Mathematical Python -Theory and Practical)

Max.Marks:75 **Time: 3Hrs.**

S.No.	Part	Type	Marks
1	**A**	**10*2 Marks=20** Two questions from each Unit, Each question carries two marks	**20**
2	**B**	**5*5=25** Two questions from each Unit with Internal Choice (either / or)	**25**
3	**C**	**3*10=30** Open Choice: Any three questions out of 5 : One question from each unit	**30**
Total Marks			**75**

- **External Question pattern Elective-VI - Mathematical Python -Theory**

Max.Marks:50 **Time: 3Hrs.**

S.No.	Part	Type	Marks
1	**A**	**5*1 Marks=5** One questions from each Unit	**5**
2	**B**	**5*3=15** Two questions from each Unit with Internal Choice (either / or)	**15**
3	**C**	**3*10=30** Open Choice: Any three questions out of 5 : One question from each unit	**30**
Total Marks			**50**

- **External Question pattern Elective-VI - Mathematical Python–Practical**

Practical		
Record	10	25
Programme and Output	10	
Viva	5	

- **Question Paper Pattern for Internal examination for Skill Enhancement Course- NME-I: OFFICE AUTOMATION AND ICT TOOLS (PRACTICAL)**

.

Max.Marks:25 **Time: 2Hrs.**

S.No.	Part	Type	Marks
1	**A**	**3*1 Marks=3** Q.No.1 to 3	**3**
2	**B**	**2*3 Marks=6** (Either or Pattern) Q.No. 4 and 5	**6**
3	**C**	**2*8 Marks=16** (Either or Pattern) Q.No. 6 and 7	**16**
Total Marks			**25**

- **Question Paper Pattern for External examination for Skill Enhancement Course- NME-I: OFFICE AUTOMATION AND ICT TOOLS (PRACTICAL)**
  Max.Marks:75

Practical		
Record	25	75
Programme and Output	25	
Viva	25	

- **Question Paper Pattern for External examination for Skill Enhancement Course- NME-II:** Mathematical documentation using LATEX

Max.Marks:25 **Time: 1Hrs.**

S.No.	Part	Type	Marks
1	**A**	**3*1 Marks=3** Q.No.1 to 3	**3**
2	**B**	**1*4 Marks=4** (Either or Pattern) Q.No. 4	**4**
3	**C**	**1*8 Marks=8** (Either or Pattern) Q.No. 5	**8**
Total Marks			**15**

Components of Continuous Assessment (Part IV)

Components		Calculation	CIA Total
CA1	15 Marks	$\frac{\mathbf{15+15}}{\mathbf{2}}$ =15	25 Marks
CA2	15 Marks		
Assignment	5 Marks	5	
Seminar	5 Marks	5	

- **Question Paper Pattern for External examination for Skill Enhancement Course- NME-II and Professional Competency Skill Enhancement Course –III**

Max.Marks:75 **Time: 3Hrs.**

S.No.	Part	Type	Marks
1	**A**	**10*2 Marks=20** Two questions from each Unit, Each question carries two marks	**20**
2	**B**	**5*5=25** Two questions from each Unit with Internal Choice (either / or)	**25**
3	**C**	**3*10=30** Open Choice: Any three questions out of 5 : One question from each unit	**30**
Total Marks			**75**

*** Minimum credits required to pass: 91**

- **Project Report**

  A student should select a topic for the Project Work at the end of the third semester itself and submit the Project Report at the end of the fourth semester. The Project Report shall not exceed 75 typed pages in Times New Roman font with 1.5 lines space.

- **Project Evaluation**

  There is a Viva Voce Examination for Project Work. The Guide and an External Examiner shall evaluate and conduct the Viva Voce Examination.

PROJECT WORK

The ratio of marks for Internal and External Examination is 25:75

THE INTERNAL COMPONENTS OF PROJECTS

Components	Semester Examination
Review	15
Regularity	10
Total	**25**

EXTERNAL VALUATION OF PROJECT WORK

Components	Marks
Project Report	50
External Viva Voce	25
Total	**75**

INTERNSHIP / INDUSTRIAL TRAINING

Duration of the Training:

- The learners of all the Under-Graduation Programmes are to undergo the Internship / Industrial Training during the summer vacation(after completion of the Second Semester examinations) 30 hours.

Evaluation:

- After completion of the training, the evaluation of the performance of the learners will be done in the III semester.
- Two credits will be awarded for the best performers.

* Viva-voce examination will be conducted and the learners have to appear for the Viva-voce individually.
* At the time of Viva-voce, the learners have to submit the given records to the examiner.
    - Work Diary, endorsed by the trainer
    - A complete report on the objectives, modules and outcomes.

A certificate, duly signed and issued by the trainer

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

Range of Marks	Grade Points	Letter Grade	Description
90 – 100	9.0 – 10.0	O	Outstanding
80-89	8.0 – 8.9	D+	Excellent
75-79	7.5 – 7.9	D	Distinction
70-74	7.0 – 7.4	A+	Very Good
60-69	6.0 – 6.9	A	Good
50-59	5.0 – 5.9	B	Average
00-49	0.0	U	Re-appear
ABSENT	0.0	AAA	ABSENT

4. Attendance

Students must have earned 75% of attendance in each course for appearing for the examination. Students with 71% to 74% of attendance must apply for condonation in the Prescribed Form with prescribed fee. Students with 65% to 70% of attendance must apply for condonation in the Prescribed Form with the prescribed fee along with the Medical Certificate. Students with attendance lesser than 65% are not eligible to appear for the examination and they shall re-do the course with the prior permission of the Head of the Department, Principal and the Registrar of the University.

5. Any Other Information

In addition to the abovementioned regulations, any other common regulations pertaining to the PG Programmes are also applicable for this Programme.

PG DEPARTMENT OF MATHEMATICS
M.Sc. Mathematics
(For the students admitted during the academic year 2023 – 2024 onwards)

S.NO	Course Code	Title of the Course	Credits	Hour		Maximum Marks		
				Theory	Practical	CIA	ESE	Total
	FIRST SEMESTER							
1		CC1 - Algebraic Structures	5	7	–	**25**	**75**	**100**
2		CC2 - Real Analysis I	5	7	–	**25**	**75**	**100**
3		CC3-Ordinary Differential Equations	4	6	–	**25**	**75**	**100**
4		Elective I(Generic / Discipline Specific) Graph Theory and Applications / Numerical Methods	3	5(4L + 1T)	–	**25**	**75**	**100**
5		Elective II(Generic / Discipline Specific) Fuzzy Sets and their Applications /Mathematical Programming	3	5(4L + 1T)	–	**25**	**75**	**100**
	Total		**20**	**30**		**125**	**375**	**500**
	SECOND SEMESTER							
6		CC4 – Advanced Algebra	5	6	–	**25**	**75**	**100**
7		CC5 – Real Analysis II	5	6	–	**25**	**75**	**100**
8		CC6 - Partial Differential Equations	4	6	–	**25**	**75**	**100**
9		Elective III(Generic / Discipline Specific) Mathematical Statistics/Statistical Data Analysis using R Programming	3	4	–	**25**	**75**	**100**
10		Elective-IV(Computer / IT related) Modeling and Simulation / Neural Networks	3	4	–	**25**	**75**	**100**
11		Skill Enhancement Course (SEC)- I: Non-Major Elective: Office Automation and ICT Tools-Practical	2		**4**	**25**	**75**	**100**
	Total		**22**	**26**	**4**	**150**	**450**	**600**

	THIRD SEMESTER							
12		CC7 - Complex Analysis	5	6	–	**25**	**75**	**100**
13		CC8 - Probability Theory	5	6		**25**	**75**	**100**
14		CC9 – Topology	5	6	–	**25**	**75**	**100**
15		CC10 - Mechanics	4	6	–	**25**	**75**	**100**
16		Elective V(Generic / Discipline Specific) Fluid Dynamics/ Stochastic Process	3	3	**-**	**25**	**75**	**100**
17		Skill Enhancement Course (SEC)-II: Non-Major Elective: Mathematical documentation using LATEX	2	3	**-**	**25**	**75**	**100**
18		Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours)	2		**-**	**100**	**-**	**100**
	Total		**26**	**30**	**-**	**250**	**450**	**700**
	FOURTH SEMESTER							
19		CC11–Functional Analysis	5	6	–	**25**	**75**	**100**
20		CC12 - Differential Geometry	5	6	–	**25**	**75**	**100**
21		CC13 - Project with viva voce	7	10	–	**25**	**75**	**100**
22		Elective VI(Generic / Discipline Specific) Mathematical Python -Theory and Practical / Financial Mathematics	3	2	**2**	**25**	**75**	**100**
23		Professional Competency Skill Enhancement Course –III: Training for Competitive Examinations • Mathematics for NET / UGC - CSIR/ SET / TRB Competitive Examinations (2 hours) • General Studies for UPSC / TNPSC / Other Competitive Examinations (2 hours)	2	4	**-**	**25**	**75**	**100**
24		Extension Activity	1	**-**	**-**	**100**	**-**	**100**
	Total		**23**	**28**	**2**	**225**	**375**	**600**
	Grand Total		**91**	**114**	**6**	**750**	**1650**	**2400**

Note:

CIA – Continuous Internal Assessment

ESE – End of Semester Examinations

Course code		Core Paper I: ALGEBRAIC STRUCTURES	L	T	P	C
Semester-I			**7**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. To provide deep knowledge about various algebraic structures.
2. To introduce Galois Theory and to see its application to the solvability of polynomial equations by radicals.

Expected Course Outcomes:

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

1	Understand Sylows theorem and its applications	K3
2	Formulate some special types of rings and their properties.	K6
3	Acquire knowledge on extension fields and roots of polynomials	K4
4	Analyze the elements of Galois theory and Galois Groups over the rationals	K4
5	Understand the basic concepts of solvability by radicals and finite fields.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Group Theory**	**21 hours**

Another Counting Principle, Sylow’s Theorem: 1st, 2nd and 3rd parts of Sylow’s Theorems – double coset – the normalizer of a group.

Unit:2	**Group Theory (contd) and Ring Theory**	**21 hours**

Direct Products: External and Internal direct Products, Euclidean Rings, A Particular Euclidean Rings, Polynomial rings.

Unit:3	**Ring Theory (contd) and Fields**	**21 hours**

Polynomials over rational fields – extension fields – roots of polynomials – splitting fields.

Unit:4	**Fields (contd)**	**21 hours**

More about roots – simple extension – fixed fields – symmetric rational functions – normal extension - Galois group – fundamental theorem of Galois theory.

Unit:5	**Fields (contd) and Selected Topics**	**21 hours**

Solvability by radicals: Solvable group – the commutator subgroup – Solvability by radicals - Finite fields.

	Total Lecture hours	**105 hours**

Text Book(s)	
1	I.N. Herstein, Topics in Algebra, Secnd Edition, John Wiley and Sons, New York, 1975. UNIT I: Chapter2 : Sections 2.11,2.12 UNIT II: Chapter2 : Section2.13 Chapter3 : Sections 3.7-3.9 UNIT III: Chapter3 : Section3.10 Chapter 5 : Sections 5.1,5.3 UNIT IV: Chapter 5 : Sections 5.5,5.6 UNIT V: Chapter 5 : Section 5.7 Chapter7 : Section7.1

Reference Books	
1	Serge Lang, Algebra, Third Edition, Addison-Wesley, Mass, 1993.
2	John B. Fraleigh, A First Course in Abstract Algebra, Addison Wesley, Mass, 1982.
3	M. Artin, Algebra, Prentice-Hall of India, New Delhi, 1991.
4	V. K. Khanna and S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House Pvt Limited, 1993.

Mapping with Programme Outcomes

COs POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P
CO1	M	L	L	L	M	S	L	S	M	M
CO2	S	S	M	L	L	S	L	S	M	S
CO3	M	L	S	M	S	M	M	L	L	S
CO4	M	L	S	S	S	M	M	L	L	S
CO5	L	M	M	S	M	L	S	M	S	M

*S-Strong; M-Medium; L-Low

Course code		Core Paper II: REAL ANALYSIS-I	L	T	P	C
Semester-I			7	0	0	5

Course Objectives:

The main objectives of this course are to:

1. To convey concepts of real valued functions in detail.
2. To provide the deep knowledge about sequences and series.
3. To make a clear difference between differentiability and continuity
4. To know some basic theorems**.**

Expected Course Outcomes:

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

1	Apply the Riemann Stieltjes integral and bring its properties and rectifiable curves.	K3
2	Remembering of sequences and series along with its properties	K1
3	Analyze the concept of linear transformation and find the extreme values of implicit functions.	K4
4	Understand the fundamental concept of Lebesgue measure.	K2
5	Evaluate the complex integration and the benefits of Lebesgue Integral	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Countable and Uncountable sets	21 hours

Finite Countable and Uncountable sets – definition of enumerable or denumerable, equivalence relation with theorems and examples- Metric spaces –Euclidean spaces examples- Basic definitions of metric spaces and its examples – Open and closed sets -Compact sets- definition of compact sets with union and intersection theorems and its properties- k- cell is compact-Weierstrass theorem

Unit:2	Perfect sets	21 hours

Introduction about Perfect sets – definition of perfect set and cantor set and its theorem- Connected sets-real line is connected property theorem- Convergent and divergence sequences in a metric space theorems –Subsequences - Cauchy sequences and complete - Upper and lower limits - Some special sequences theorems and examples– Series – harmonic series and geometric series examples - The number e - The root and ratio tests and its examples

.

Unit:3	Power series	21 hours

Definition of Power series – radius of convergence with problems - Summation by parts – partial summation formula-Leibnitz theorem-absolute convergence – conditionally convergent - definition and theorems and its examples-addition and multiplication of series with problems – Rearrangements

Unit:4	**Continuity function**	**21 hours**
Continuity: Limits of functions - Continuous functions and their properties and theorems- continuity and compactness- uniform continuous-theorems -The derivative of a real function with properties and examples-Mean value theorems and generalized Mean value theorem- The continuity of derivatives - L‟Hospital‟ rule		
Unit:5	**The Riemann-Stieltjes Integral**	**21 hours**
Introduction of Riemann-Stieltjes Integral: Definition and existence of the integral – definition of refinement -upper and lower partition theorems-Properties of the Riemann-Stieltjes Integral and its theorems- definition of unit step function-Integration and differentiation –fundamental theorem of calculus- integration by parts- Integration of vector valued functions.		
	Total Lecture hours	**105 hours**

Text Book(s)

1	1. **Walter Rudin**, "Principles of Mathematical Analysis", 3rd Edition, McGraw –Hill International Book Company, Singapore,(1982). Units I: Chapter- 2: 2.1 to 2.42 Unit II: Chapter- 2: 2.43 to 2.47 and Chapter -3:3.1 to 3.37 Unit III: Chapter- 3: 3.38 to 3.58 Unit IV: Chapter-4: 4.1 to 4.21 and Chapter -5: 5.1 to 5.13 Unit V: Chapter- 6:6.1 to 6.23

Reference Books

1	R. G. Bartle, Elements of Real Analysis, 2nd Edition, John Wily and Sons, New York, 1976.
2	**S. Kumaresan**, "Topology of Metric Spaces ", 2^{nd}Edition, Narosa Publishing House, 2011
3	**S. Ponnusamy**, "Foundations of Mathematical Analysis", Springer Birkhauser,2012
4	**G.F.Simmons,** "Introduction to Topology and Modern Analysis", McGraw –Hill, New Delhi,2004.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://www.youtube.com/watch?v=DO0Dzz07DNI
2	https://nptel.ac.in/courses/111/101/111101100/
3	https://www.youtube.com/watch?v=Y5yEMXZnzYw
4	https://youtu.be/msIZz8ydzcM

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**L**	**S**	**S**	**M**	**S**	**M**	**S**	**S**	**S**	**S**
CO3	**S**	**M**	**M**	**L**	**S**	**S**	**S**	**L**	**L**	**L**
CO3	**L**	**M**	**S**	**L**	**M**	**M**	**M**	**S**	**M**	**S**
CO4	**L**	**M**	**S**	**L**	**M**	**S**	**S**	**S**	**M**	**M**
CO5	**M**	**L**	**S**	**M**	**S**	**L**	**M**	**M**	**L**	**L**

*S-Strong; M-Medium; L-Low

Course code		Core Paper III: ORDINARY DIFFERENTIAL EQUATIONS	L	T	P	C
Semester-I			**6**	**0**	**0**	**4**

Course Objectives:

The main objectives of this course are to:

1. Study Solutions of Linear differential equations with constant and variable coefficients.
2. Understand and able to apply various theoretical ideas that underlined in existence and uniqueness theorems, Linear independence and dependence, Wronskian etc.,
3. Enables the students to develop the strong background on modeling, formulating, solving and interpreting physical problems.

Expected Course Outcomes:

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

1	Recall the types of linear homogeneous equations of second order equations with constant coefficients and apply the method to solve.	K1
2	Analyze non-homogeneous ODE using the method of undermined coefficients and annihilator method to solve the same.	K4
3	Understand and Apply the theorems on Initial value problem to ordinary differential equations.	K2, K3
4	Comprehend the Euler equations, the Bessel's equation and Regular, Singular points at infinity and to evaluate.	K5
5	Identify the research problem where differential equation can be used to model the problem.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Linear Equations with Constant Coefficients**	**18 hours**

Introduction - Second order homogenous equations - Initial value problem for second order equations - Linear dependence and independence - A formula for Wronskian..

Unit:2	**Linear Equations with Constant Coefficients (Contd)**	**18 hours**

The Non- homogenous equations of order two-homogenous and Non - homogenous equations of order n - Initial value problems for n^{th}order equations.

Unit:3	**Linear Equations with Variable Coefficients**	**18 hours**

Initial value problem - Existence and uniqueness theorem - The Wronskian and linear independence - Reduction of the order of a homogenous equation - The non- Homogenous equation - Homogenous equations with analytic coefficients - The Legendre equations.

Unit:4	**Linear Equations with Regular Singular Points**	**18 hours**

The Euler equations - Second order equations with regular singular points - Exceptional cases - The Bessel equation – The Bessel equation contd.

Unit:5	**Existence and Uniqueness of Solutions to First Order Equations**	**18 hours**

Equations with variable separated - Exact equations - The method of successive approximation - The Lipschitz Condition - Convergence of the successive approximation. Non- local existence of solution – Approximations and uniqueness of solutions		
	Total Lecture hours	**90 hours**

Text Book(s)	
1	Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice-Hall of India Private Limited, New Delhi2008. UNIT I: Chapter2 : Sections 2.1 –2.5. UNIT II: Chapter2 : Sections 2.6 – 2.8, 2.10. UNIT III: Chapter3 : Sections 3.1 –3.8 UNIT IV: Chapter4 : Sections 4.1 – 4.4, 4.6 –4.8 UNIT V: Chapter5 : Sections 5.1 –5.8
Reference Books	
1	Williams E. Boyce and Richard C. Diprima, Elementary Differential Equations and Boundary Value Problems, 10th edition, John Wiley and Sons, New York
2	S. G. Deo and V. Raghavendra, Ordinary Differential Equations and Stability Theory, Tata McGraw-Hill, New Delhi 1980.
3	George F. Simmons, Differential Equations with Application and Historical Notes, Tata McGraw Hill, New Delhi 1974.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**S**	**S**	**M**	**M**	**S**	**L**	**S**	**M**	**S**	**L**
CO3	**M**	**S**	**S**	**M**	**S**	**S**	**S**	**S**	**S**	**M**
CO3	**L**	**M**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
CO4	**M**	**S**	**L**	**M**	**S**	**M**	**S**	**S**	**L**	**S**
CO5	**L**	**M**	**S**	**S**	**S**	**M**	**S**	**S**	**L**	**M**

*S-Strong; M-Medium; L-Low

Course code		Elective -I: GRAPH THEORY AND APPLICATIONS	L	T	P	C
Semester-I			4	1	0	3

Course Objectives:

The main objectives of this course are to:

1. To provide deep knowledge about fundamental concepts of Graphs and Trees.
2. To introduce Matchings, Coloring, and Chromatic Number and to see its application in higher order thinking.

Expected Course Outcomes:

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

1	Understand the basic concepts of Graphs and Trees	K2
2	Analyze vertex and edge connectivity concepts	K4
3	Acquire knowledge in Matching and Colourings	K4
4	Apply Chromatic Number	K3
5	Determining the planar, non-planar, and directed graphs	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Graphs, Subgraphs and Trees	15 hours

Graphs, Subgraphs: Graphs and Simple Graphs– Graph Isomorphism – The Incidence and Adjacency matrices, Subgraphs – Vertex Degrees – paths and Connection – Cycles.
Trees: Trees – Cut edges and Bonds – cut vertices

Unit:2	Connectivity, Euler tours and Hamilton Cycles	15 hours

Connectivity: Connectivity – Blocks – Vertex connectivity – Edge connectivity.
Euler tours and Hamilton Cycles: Euler tours - Hamilton Cycles.

Unit:3	Matchings and Edge Colourings	15 hours

Matchings: Matchings coverings in Bipartite Graphs – Perfect Matchings.
Edge colourings: Edge chromatic number – Vizing's theorem.

Unit:4	Independent sets, Cliques and Vertex Colourings	15 hours

Independent sets, Cliques: Independent sets – Ramsey's theorem.
Vertex Colourings: Chromatic Number – Brook's Theorem – Chromatic polynomial

Unit:5	Planar Graphs and Directed Graphs	15 hours

Planar Graphs: Plane and planar Graphs - K_5 non-planar graph – Dual Graphs – Euler's formula – Brides – Kuratowski's theorem (Proof omitted)- The five colours theorem and four colour conjection

	Total Lecture hours	**75**

Text Book(s)	
1	J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, American Elsevier Company Inc., New York, 1976. Unit-I: Sections: 1.1 – 1.7, 2.1 – 2.3 Unit-II: Sections: 3.1 – 3.2, 4.1 – 4.2 Unit-III: Sections: 5.1 – 5.3, 6.1 – 6.2 Unit-IV: Sections: 7.1 – 7.2, 8.1 – 8.2, 8.4 Unit-V: Sections: 9.1 – 9.4, 9.6
Reference Books	
1	Frank Harary, Graph Theory, Addison-Wesley, Reading, 1969.
2	M.Murugan, Graph Theory and Algorithms, Second Edition, Muthali Publishing House, Chennai, 2018.
3	K. R. Parthasarathy, Basic Graph Theory, Tata McGraw Hill, New Delhi, 1994.
4	Douglas B. West, Introduction to Graph Theory, Prentice Hall of India, 2001.

Mapping with Programme Outcomes

COs POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO**
CO1	**L**	**M**	**M**	**L**	**M**	**M**	**M**	**S**	**M**	**S**
CO2	**M**	**S**	**S**	**M**	**M**	**L**	**L**	**S**	**M**	**S**
CO3	**S**	**S**	**S**	**M**	**L**	**L**	**L**	**M**	**L**	**M**
CO4	**L**	**M**	**S**	**S**	**M**	**L**	**M**	**S**	**M**	**M**
CO5	**M**	**L**	**S**	**M**	**M**	**M**	**M**	**S**	**M**	**S**

*S-Strong; M-Medium; L-Low

<table>
<tr><td>Course code</td><td></td><td>ELECTIVE-I: NUMERICAL METHODS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Semester-I</td><td></td><td>4</td><td>1</td><td>0</td><td>3</td></tr>
</table>

Course Objectives:

The main objectives of this course are to:

1. To make the students understand solving Algebraic and Transcendental equations.
2. To know about how and when to use various interpolation function finding the various numerical differentiation and integration formulae and using them to solve problems.

Expected Course Outcomes:

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

1	Solve problems in numerical differentiation and integration	K3
2	Solve system of equations using various methods.	K3
3	Apply various methods to find numerical solution of first and second order ordinary differential equations.	K3
4	Explain the various methods for solving Boundary Value Problems and Characteristic Value Problems	K2
5	Understand the Explicit method and the Crank Nicolson method for solving partial differential equations.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Solution of Nonlinear Equations, Numerical Differentiation and**	**15 hours**

Solution of Nonlinear Equations: Newton's method – Convergence of Newton's method.

Numerical Differentiation and Integration: Derivatives from Differences tables – Higher order derivatives – Divided difference, Central-Difference formulas– Composite formula of Trapezoidal rule – Romberg integration – Simpson's rules. (Section 1.3, 1.5, 5.2, 5.3)

Unit:2	**Solution of System of Equations**	**15 hours**

The Elimination method – Gauss and Gauss Jordan methods – LU Decomposition method – Matrix inversion by Gauss-Jordan method – Methods of Iteration – Jacobi and Gauss Seidal Iteration. (Section 2.2-2.5)

Unit:3	**Solution of Ordinary Differential Equations**	**15 hours**

Taylor series method – Euler and Modified Euler methods – Runge-kutta methods – Milne's method. (Section 6.1-6.4)

Unit:4	**Boundary Value Problems and Characteristic Value Problems**	**15 hours**

The shooting method – solution through a set of equations – Derivative boundary conditions – Characteristic value problems – Eigen values of a matrix by Iteration – The power method. (Section 6.7, 6.8)

Unit:5	Numerical Solution of Partial Differential Equations	15 hours
Elliptic and Parabolic– Laplace's equation on a rectangular region – Iterative methods for Laplace equation – The Poisson equation – Derivative boundary conditions – Solving the equation for time-dependent heat flow (i) The Explicit method (ii) The Crank Nicolson method. (Section 8.1, 8.2)		
	Total Lecture hours	**75 hours**

Text Book(s)	
1	Curtis F. Gerald, Patrick O. Wheatley, Applied Numerical Analysis, 7th Edition, Addison Wesley, (1998).
Reference Books	
1	S. C. Chapra and P. C. Raymond: Numerical Methods for Engineers, Tata McGraw Hill, New Delhi, 2000.
2	S.S. Sastry: Introductory methods of Numerical Analysis, Prentice Hall of India, New Delhi, 1998.
3	P. Kandasamy et al., Numerical Methods, S.Chand&Co.Ltd., New Delhi, 2003.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**S**	**M**	**L**	**S**	**S**	**M**	**L**	**S**	**M**	**M**
CO3	**S**	**M**	**L**	**S**	**S**	**M**	**L**	**S**	**M**	**M**
CO3	**S**	**M**	**L**	**S**	**S**	**M**	**L**	**S**	**M**	**M**
CO4	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**M**	**L**	**L**
CO5	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**M**	**L**	**L**

*S-Strong; M-Medium; L-Low

Course code		**Elective-II FUZZY LOGIC AND FUZZY SETS**	**L**	T	**P**	**C**
Semester-I			**4**	**1**	**0**	**3**

Course Objectives:

The main objectives of this course are to:
1. Identify fuzzy sets and perform set operations on fuzzysets.
2. Apply fuzzy logic in various real-life situations such as decision making and inventory control.

Expected Course Outcomes:

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

1	Gain knowledge about the basic types of fuzzy sets and the difference between crisp sets and fuzzy sets and the concept of operations on fuzzy sets	K1, K2
2	Analyze and apply the knowledge of fuzzy relations.	K3,K4
3	Develop the basic concepts of fuzzy measures.	K6
4	Explore the concept of uncertainity.	K6
5	Understand the types of uncertainity measures and principles	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	**Crisp Sets and Fuzzy Sets**	**15 hours**

Introduction- Crisp sets: An over view- The Notion of Fuzzy Sets- basic concepts of Fuzzy Sets – Additional properties of α-cuts – representation of fuzzy sets

Unit:2	**Operation on Fuzzy Sets**	**15 hours**

Types of operation – fuzzy complements - - fuzzy intersection t- Norms-fuzzy union t - Norms

Unit:3	**Possibility Theory**	**15 hours**

Fuzzy measures - Evidence Theory –possibility Theory - fuzzy sets and possibility theory-possibility Theory versus probability Theory

Unit:4	**Fuzzy Measures, Uncertainty**	**15 hours**

Relationship among classes of fuzzy measures - Types of Uncertainty – Measures of Fuzziness-Classical Measures of Uncertainty.

Unit:5	**Uncertainty and Information**	**15 hours**

Measures of Dissonance-Measures of Confusion – Measures of Non-Specificity – Uncertainty and Information – Information and Complexity.

	Total Lecture hours	**75 hours**

Text Book(s)	
1	George J. Klir and Tina A. Folger, Fuzzy Sets, Uncertainty and Information, Fourth printing, Prentice Hall of India Private Limited, 1995. Unit-I: 1.1 – 1.4, 2.1 – 2.2 Unit-II: 3.1 -3.4 Unit-III: 7.1 - 7.5 Unit-IV: 9.1- 9 4 Unit-V: 9.5-9.7
Reference Books	
1	George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic - Theory and Applications, Prentice-Hall of India Private Limited
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://giocher.wordpress.com/chapter-2-par-2-2-fuzzy-relations-and-the-extension- principle/
2	https://nptel.ac.in/courses/108/104/108104157/

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	S	L	M	L	S	M	S	S
CO2	M	S	M	S	S	S	S	S	S	S
CO3	S	S	L	M	S	S	L	M	L	S
CO4	S	S	L	M	S	S	L	M	L	S
CO5	M	S	M	S	S	S	S	S	M	S

*S-Strong; M-Medium; L-Low

Course code		Elective-II : MATHEMATICAL PROGRAMMING	L	T	P	C
Semester-I			4	1	0	3

Course Objectives:

The main objectives of this course are to:
1. To make the students understand and solving LPP using various method.
2. To understand the concept of Kuhn tucker method.

Expected Course Outcomes:

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

1	Understand the formulation of linear programming problem.	K2
2	Remember various techniques to solve real life problem.	K1
3	Understand and solve the non-linear programming problem.	K2,K5
4	Apply the fundamental concepts of Parametric Programming and Integer Linear Programming	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Linear Programming Problem	15 hours

Formulation of Linear Programming problem – Graphical solution - Simplex procedure – method of penalty – Two – Phase technique – special cases in simplex method applications – Duality – Economic interpretation of duality – Primal Dual Computations

Unit:2	Dynamic Programming Problem	15 hours

Generalized simplex Tableau in Matrix form – Efficient Computational algorithm – Deterministic Dynamic Programming

Unit:3	Integer Linear Programming Problem	15 hours

Parametric Programming and Integer Linear Programming

Unit:4	Classical Optimization Theory	15 hours

Unconstrained Problem – Necessary and Sufficient conditions, Constrained Problems – Equality (Jacobi method and Lagrangian method) and un equality constrains (Extension of Lagrangian method and Kuhn-Tucker Conditions)

Unit:5	Non-Linear Programming	15 hours

Unconstrained non-linear algorithms – Direct search Method and Gradient Method – Constrained algorithms – Separable, quadratic, geometric programming.

	Total Lecture hours	**75 hours**

Text Book(s)

1	Hamdy A. Taha, "Operations Research", (sixth edition) Prentice – Hall of India Private Limited, New Delhi, 1997. Unit I: Chapter 2 : Section 2.1 - 2.3 Chapter 3 : Section 3.1 - 3.5 Chapter 4 : Section 4.1 - 4.6 Chapter 7 : Section 7.6 only Unit II: Chapter 4 : Section 4.7 only Chapter 7 : Section 7.4, 7.5.1 and 7.5.2 Chapter 10 : Section 10.2 - 10.5 Unit III: Chapter 7 : Section 7.7 Chapter 9 : Section 9.1 - 9.3 Unit IV: Chapter 20 : Section 20.1 - 20.3 omit 20.2.2. Unit V: Chapter 21 : Section 21.1, 21.2 omit 21.2.4, 21.2..5 and 21.2.6.

Reference Books

1	F.S. Hiller and J.Lieberman, Introduction to Operation Research (7th Edition) Tata – McGraw Hill Publishing Company, New Delhi, 2001.
2	C. Beightler, D. Philips and B. Wilde, Foundations of Optimization (2nd Edition) Prentice Hall Pvt. Ltd., New York, 1979.
3	M.s.Bazaraa, J.J. Jarvis and H.D. Sharall, Linear Programming and Network flow, John Wiley, New York, 1990

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**L**	**M**	**S**	**L**	**M**	**L**	**S**	**M**	**S**	**S**
CO2	**M**	**S**	**M**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
CO3	**S**	**S**	**L**	**M**	**S**	**S**	**L**	**M**	**L**	**S**
CO4	**S**	**S**	**L**	**M**	**S**	**S**	**L**	**M**	**L**	**S**
CO5	**M**	**S**	**M**	**S**	**S**	**S**	**S**	**S**	**M**	**S**

*S-Strong; M-Medium; L-Low

Course code		Core Paper IV:ADVANCED ALGEBRA	L	T	P	C
Semester-II			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. Develop a strong foundation in linear algebra that provide a basic for advance dstudies.
2. Study of Linear Transformations, Algebra of Polynomials, Invariant space and their properties.
3. Give particular attention to canonical forms of linear transformations, diagonalizations of linear transformations, matrices and determinants.

Expected Course Outcomes:

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

Understand the basic concepts of Linear transformations, characteristic roots and matrices of linear transformation and its applications.	K2
Explain about the algebra of polynomials, polynomial ideals and prime factorization of a polynomial.	K2, K4
Understand the basic concepts of determinants and its additional properties.	K2
Recognize the concepts of Invariant subspaces and diagonalization process.	K5
Analyze canonical Form, Jordan Form and Rational canonical Form.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Linear Transformations**	**18 hours**

Linear transformations – Isomorphism of vector spaces – Representations of linear transformations by matrices – Linear functionals.

Unit:2	**Algebra of Polynomials**	**18 hours**

The algebra of polynomials –Polynomial ideals - The prime factorization of a polynomial - Determinant functions.

Unit:3	**Determinants**	**18 hours**

Permutations and the uniqueness of determinants – Classical adjoint of a (square) matrix – Inverse of an invertible matrix using determinants – Characteristic values – Annihilating polynomials.

Unit:4	**Diagonalization**	**18 hours**

Invariant subspaces – Simultaneous triangulations – Simultaneous diagonalization – Direct-sum decompositions – Invariant direct sums – Primary decomposition theorem.

Unit:5	**The Rational and Jordan Forms**	**18 hours**

Cyclic subspaces – Cyclic decompositions theorem (Statement only) – Generalized Cayley – Hamilton theorem - Rational forms – Jordan forms.

	Total Lecture hours	**90 hours**

Text Book(s)	
1	Kenneth M Hoffman and Ray Kunze, Linear Algebra, Second Edition, Prentice-Hall of India Pvt. Ltd, New Delhi, 2013. UNITI: Chapter3 : Sections3.1-3.5 UNITII: Chapter4 : Sections 4.1, 4.2, 4.4,4.5 Chapter5 : Sections 5.1,5.2 UNITIII: Chapter5 : Sections 5.3,5.4 Chapter6 : Sections6.1-6.3 UNITIV: Chapter6 : Sections 6.4 -6.8 UNITV: Chapter7 : Sections 7.1 –7.3

Reference Books	
1	M. Artin, Algebra, Prentice-Hall of India Pvt. Ltd., 2005.
2	S. H. Friedberg, A. J. Insel and L. E. Spence, Linear Algebra, Fourth Edition, Prentice-Hall of India Pvt. Ltd., 2009.
3	I. N. Herstein, Topics in Algebra, Second Edition, Wiley Eastern Ltd, New Delhi, 2013.

Mapping with Programme Outcomes

C	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
C	S	S	M	L	M	S	S	S	M	M
C	M	S	S	M	L	S	S	S	M	M
C	S	S	M	L	M	S	S	S	M	M
C	L	M	L	S	M	S	M	M	L	L
C	M	S	S	M	L	S	S	S	M	M

*S-Strong; M-Medium; L-Low

Course code		Core Paper VI: REAL ANALYSIS-II	L	T	P	C
Semester-II			6	0	0	5

Course Objectives:

The main objectives of this course are to:

1. To convey concepts of real valued functions in detail.
2. To provide the deep knowledge about sequences and series.
3. To make a clear difference between differentiability and continuity
4. To know some basic theorems**.**

Expected Course Outcomes:

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

1	Apply the Riemann Stieltjes integral and bring its properties and rectifiable curves.	K3
2	Remembering of sequences and series along with its properties	K1
3	Analyze the concept of linear transformation and find the extreme values of implicit functions.	K4
4	Understand the fundamental concept of Lebesgue measure.	K2
5	Evaluate the complex integration and the benefits of Lebesgue Integral	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Measurable sets and Measurable functions	18 hours

Measure on the Real line- Lebesgue Outer Measure - Measurable sets - Regularity - Measurable Functions - Borel and Lebesgue Measurability

Chapter - 2 Sec 2.1 to 2.5 (de Barra)

Unit:2	Integration of Functions of a Real variable	18 hours

Integration of Non- negative functions - The General Integral - Riemann and Lebesgue Integrals

Chapter - 3 Sec 3.1,3.2 and 3.4 (de Barra)

Unit:3	Fourier Series and Fourier Integrals	18 hours

Introduction - Orthogonal system of functions - The theorem on best approximation - The Fourier series of a function relative to an orthonormal system - Properties of Fourier Coefficients - The Riesz-Fischer Thorem - The convergence and representation problems in for trigonometric series - The Riemann - Lebesgue Lemma - The Dirichlet Integrals - An integral representation for the partial sums of Fourier series - Riemann's localization theorem - Sufficient conditions for convergence of a Fourier series at a particular point – Cesarosummability of Fourier series- Consequences of Fejes's theorem - The Weierstrass approximation theorem

Chapter 11 : Sections 11.1 to 11.15 (Apostol)

Unit:4	Multivariable Differential Calculus	18 hours

Introduction - The Directional derivative - Directional derivative and continuity - The total derivative - The total derivative expressed in terms of partial derivatives - The matrix of linear function - The Jacobian matrix - The chain rule - Matrix form of chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives - Taylor's theorem for functions of R^n to R^1 **Chapter 12 : Section 12.1 to 12.14 (Apostol)**		
Unit:5	**Implicit Functions and Extremum Problems**	**18 hours**
Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem-Extrema of real valued functions of severable variables-Extremum problems with side conditions. **Chapter 13 : Sections 13.1 to 13.7 (Apostol)**		
	Total Lecture hours	**90 hours**

Text Book(s)

1. G. de Barra, *Measure Theory and Integration*, Wiley Eastern Ltd., New Delhi, 1981. (for Units I and II)
2. TomM.Apostol : *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974. (for Units III, IV and V)

Reference Books

1. Burkill,J.C.*TheLebesgue Integral*, Cambridge University Press, 1951
2. Munroe,M.E.*Measure and Integration*. Addison-Wesley, Mass.1971.
3. Roydon,H.L.*Real Analysis*, Macmillan Pub. Company, New York, 1988.
4. Rudin, W. *Principles of Mathematical Analysis*, McGraw Hill Company, New York,1979.

Course code		Core Paper VI:PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
Semester-II			6	0	0	4

Course Objectives:

The main objectives of this course are to:

1. Introduce different methods to solve partial differential equation.
2. Acquire knowledge in classification of partial differential equations and the methods to solve.
3. Enables the students to find the solution of Partial Differential Equation of practical application like in Engineering, Physics, etc.,

Expected Course Outcomes:

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

1	Understand and remember the physical situations with real world problems to construct mathematical models using partial differential equations and study the methods to solve.	K1 &K 2
2	Analyze the type of partial differential equations and different methods to	K4
3	Evaluate Laplace equation and analyze its applications.	K5
4	Apply variable separable method to solve Laplace and Diffusion equation	K3
5	Finding the appropriate method to solve the partial differential equations	K6

K1 - Remember; **K2** – Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Partial Differential Equations of the First Order	18 hours

Partial Differential Equations – Origins of First Order Differential Equations – Cauchy's Problem for first order equations – Linear Equations of the first order – Nonlinear partial differential equations of the first order – Cauchy's method of characteristics – Compatible system of First order Equations – Solutions satisfying Given Condition, Jacobi's method.

Unit:2	Partial Differential Equations of the Second Order	18 hours

The Origin of Second Order Equations – Linear partial Differential Equations with constant coefficients – Equations with variable coefficients – Separation of variables – The method of Integral Transforms – Non – linear equations of the second order.

Unit:3	Laplace's Equation	18 hours

Elementary solutions of Laplace equation – Families of Equipotential Surfaces – Boundary value problems – Separation of variables – Surface Boundary Value Problems – Separation of Variables – Problems with Axial Symmetry – The Theory of Green's Function for Laplace Equation.

Unit:4	The Wave Equation

The Occurrence of the wave equation in Physics – Elementary Solutions of the One – dimensional Wave equations – Vibrating membrane, Application of the calculus of variations – Three dimensional problem – General solutions of the Wave equation.

Unit:5	The Diffusion Equation	18 hours
Elementary Solutions of the Diffusion Equation – Separation of variables – The use of Integral Transforms – The use of Green’s functions.		
	Total Lecture hours	**90 hours**
Text Book(s)		
1	Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill International Book Company, New Delhi, 1983.	
Reference Books		
1	M. D. Raisinghania, Advanced Differential Equations, S. Chand and Company Ltd., New Delhi, 2001.	
2	K. SankaraRao, Introduction to Partial Differential Equations, Second edition, Prentice-Hall of India, New Delhi, 2006.	
3	J. N. Sharma and K. Singh, Partial Differential Equations for Engineers and Scientists, Narosa Publishing House, 2001.	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://www.youtube.com/watch?v=bPPWp65qpIA	

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**M**	**M**	**M**	**L**	**M**	**M**	**M**	**S**	**L**	**M**
CO2	**M**	**M**	**S**	**M**	**S**	**S**	**S**	**S**	**M**	**L**
CO3	**L**	**S**	**M**	**S**	**S**	**S**	**M**	**S**	**L**	**L**
CO4	**M**	**S**	**M**	**S**	**S**	**S**	**S**	**S**	**L**	**L**
CO5	**M**	**S**	**M**	**S**	**S**	**S**	**M**	**S**	**M**	**M**

*S-Strong; M-Medium; L-Low

Course code		Elective-III:MATHEMATICAL STATISTICS	L	T	P	C
Semester-III			4	0	0	3

Course Objectives:

The main objectives of this course are to:

1. Enables to learn different aspects of statistics.
2. Acquire knowledge about moments and properties of theoretical distributions.
3. Study unbiasedness and consistency of limiting distributions.

Expected Course Outcomes:

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

1	Remembering the understanding the basic concepts such as statistics, probability and random variables.	K1, K2
2	Applying the concepts and methods to find the moments of the distributions.	K3
3	Study multivariate distributions and the independence of random variables. Further evaluating the marginal distributions from bivariate	K5
4	Analyze and study the properties of some discrete as well as continuous distributions	K4
5	Understand the convergence of distributions and central limit theorem.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Probability and Distributions	12 hours

Introduction - Set Theory - The Probability Set Function - Conditional Probability and Independence –Random Variables.

Unit:2	Probability and Distributions (continued) and Multivariate Distributions	12 hours

Probability and Distributions: Expectation of a Random Variables - Some Special Expectations - Important Inequalities.
Multivariate Distributions: Distributions of Two Random Variables - Transformations: Bivariate Random Variables.

Unit:3	Some Special Distributions	12 hours

The Binomial and Related Distributions - The Poisson Distribution - The Γ, $\chi 2$, and β Distributions.

Unit:4	Some Special Distributions (continued), Unbiasedness, Consistency and Limiting Distributions	12 hours

Some Special Distributions (continued): The Normal Distribution- t and F-Distributions.

Unit:5	Some Special Distributions (continued), Unbiasedness, Consistency and Limiting	12 hours

Unbiasedness, Consistency and Limiting Distributions: Expectations of Functions - Convergence in Probability - Convergence in Distribution - Central Limit Theorem.

	Total Lecture hours	60 hours
Text Book(s)		
1	Robert V. Hogg, Allen T. Craig and Joseph W. McKean, Introduction to Mathematical Statistics, Sixth Edition, Pearson Education, 2005. Unit-I: 1.1 –1.5 Unit-II: 1.8 – 1.10, 2.1 – 2.2 Unit-III: 3.1 –3.3 Unit-IV: 3.4, 3.6, Unit-V: 4.1 –4.4	
Reference Books		
1	Michael J. Crawley, The R Book, John Wiley & Sons, Second Edition (2013).	
2	MarekFisz, Probability Theory and Mathematical Statistics, John Wiley.	
3	Vijay K. Rohatgi and A.K. Md. EhsanesSaleh, An Introduction to Probability and Statistics, Wiley India, Second Edition (2001).	
4	M. Rajagopalan and P. Dhanavanthan, Statistical Inference, PHI Learning Pvt. Ltd., New Delhi (2012).	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://nptel.ac.in/courses/111/104/111104032/#	
2	https://nptel.ac.in/courses/111/105/111105090/	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO
CO1	S	M	M	L	L	M	S	S	S	S
CO2	M	S	M	L	S	S	M	S	S	S
CO3	S	M	S	M	M	S	S	M	L	S
CO4	M	M	S	M	M	S	M	S	M	S
CO5	M	M	L	M	S	M	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code		Elective-III: STATISTICAL DATA ANALYSIS USING R PROGRAMMING	L	T	P	C
Semester-III			4	0	0	3

Course Objectives:

The main objectives of this course are to:

1. Enables to learn different aspects of statistical data analysis.
2. Acquire knowledge about R programming in statistics.
3. Analyze the statistical data using R programming.

Expected Course Outcomes:

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

1	Apply R programming and understand different data sets	K3
2	Apply R Programme and construct graphs and charts	K3
3	Analyze the data and know descriptive statistics by using R Programming	K4
4	Apply R Programming to test the hypothesis of the study	K3
5	Predict the data and take decisions through R programming.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Introduction to R programming	12 hours

What is R? - Installing R and R Studio – R Studio Overview - Working in the Console - Arithmetic Operators - Logical Operations - Using Functions - Getting Help in R and Quitting R Studio Installing and loading packages.

Data structures, variables, and data types in R: Creating Variables - Numeric, Character and Logical Data - Vectors - Data Frames - Factors -Sorting Numeric, Character, and Factor Vectors - Special Values.

Unit:2	Data Visualization using R	12 hours

Scatter Plots - Box Plots - Scatter Plots and Box and-Whisker Plots Together -Customize plot axes, labels, add legends, and add colours.

Unit:3	Descriptive statistics in R	12 hours

Measures of central tendency - Measures of variability - Skewness and kurtosis - Summary functions, describe functions, and descriptive statistics by group.

Unit:4	Testing of Hypothesis using R	12 hours

T-test, Paired Test, correlation, Chi Square test, Analysis of Variance and Correlation

Unit:5	Predictive Analytics	12 hours
Linear Regression model, Non-Linear Least Square, multiple regression analysis, Logistic Regression, Panel Regression Analysis, ARCH Model, GARCH models, VIF model.		
	Total Lecture hours	**60 hours**

Text Book(s)

1	Crawley, M. J. (2006), "Statistics - An introduction using R", John Wiley, London 32
2	Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015), "Statistics using R", second edition. Narosa Publishing House, New Delhi.
3	Shahababa B. (2011) , "Biostatistics with R", Springer, New York
4	Braun & Murdoch (2007), "A first course in statistical programming with R", Cambridge University Press, New Delhi.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	L	M	S	S	S	S
CO2	M	S	M	L	S	S	M	S	S	S
CO3	S	M	S	M	M	S	S	M	L	S
CO4	M	M	S	M	M	S	M	S	M	S
CO5	M	M	L	M	S	M	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code		Elective -IV:MODELLING AND SIMULATION	L	T	P	C
Semester-II			**4**	**0**	**0**	**3**

Course Objectives:

The main objectives of this course are to:

1. Define the basics of simulation modeling and replicating the practical situations in organizations.
2. Develop simulation model using heuristic methods.
3. Analysis of Simulation models using input analyzer, and output analyzer
4. Explain Verification and Validation of simulation model.

Expected Course Outcomes:

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

1	Describe the role of important elements of discrete event simulation and modeling paradigm.	K2, K4
2	Conceptualize real world situations related to systems development decisions, originating from source requirements and goals.	K2
3	Develop skills to apply simulation software to construct and execute goal-driven system models.	K6
4	Interpret the model and apply the results to resolve critical issues in a real world environment	K3, K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Introduction to Simulation**	**12 hours**

Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system.

Unit:2	**Model of a system**	**12 hours**

Model of a system, types of models, steps in a simulation study. Simulation Examples: Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples.

Unit:3	**General Principles and Random Numbers**	**12 hours**

Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling. Random Numbers: Properties, Generations methods.

Unit:4	**Analysis of Simulation Data**	**12 hours**

Input Modelling: Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data.

Unit:5	**Analysis of Simulation Data (Contd)**	**12 hours**

Multivariate and time series analysis - Verification and Validation of Model – Model Building, Verification, Calibration and Validation of Models.

		Total Lecture hours	**60 hours**

Text Book(s)	
1	Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9.
2	Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.
3	Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.
4	NarsinghDeo, Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, 2004, ISBN : 0-87692-028-8.
Reference Books	
1	Averill M. Law, ”Simulation Modeling and Analysis”, 4/e, Tata McGraw-Hill, 2017.
2	Lawrence M. Leemis and Stephen K. Park, ”Discrete – Event Simulation: A First Course”,Pearson Education, 2006.

Mapping with Programme Outcomes

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	**S**	**L**	**M**	**M**	**M**	**L**	**M**	**S**	**S**	**M**
CO2	**S**	**M**	**M**	**L**	**L**	**L**	**L**	**M**	**M**	**M**
CO3	**L**	**M**	**M**	**S**	**L**	**L**	**L**	**M**	**M**	**M**
CO4	**M**	**M**	**L**	**L**	**M**	**L**	**L**	**L**	**M**	**S**
CO5	**M**	**M**	**M**	**L**	**L**	**L**	**L**	**S**	**M**	**M**

*S-Strong; M-Medium; L-Low

Course code		Elective -IV:NEURAL NETWORKS	L	T	P	C
Semester-II			4	0	0	3

Course Objectives:

The main objectives of this course are to:

1. To know the main fundamental principles and techniques of neural network systems and investigate the principal neural network models and applications.
2. Acquire in-depth knowledge in Non-linear dynamics
3. Apply neural network to classification and generalization problems.

Expected Course Outcomes:

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

1	Understand and analyze different neutron network models	K2, K4
2	Understand the basic ideas behind most common learning algorithms for multilayer perceptions, radial-basis function networks.	K2
3	Describe Hebb rule and analyze back propagation algorithm with examples.	K4
4	Study convergence and generalization and implement common learning algorithm,	K1, K2
5	Study directional derivatives and necessary conditions for optimality and to evaluate quadratic functions.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Neuron Model and Network Architectures**	**12 hours**

Mathematical Neuron Model- Network Architectures- Perceptron-Hamming Network- Hopfield Network-Learning Rules.

Unit:2	**Perceptron Architectures**	**12 hours**

Perceptron Architectures and Learning Rule with Proof of Convergence. Supervised Hebbian Learning -Linear Associator.

Unit:3	**Supervised Hebbian Learning**	**12 hours**

The Hebb Rule-Pseudo inverse Rule-Variations of Hebbian Learning-Back Propagation - Multilayer Perceptrons.

Unit:4	**Back Propagation**	**12 hours**

Back propagation Algorithm-Convergence and Generalization - Performances Surfaces and Optimum Points-Taylor series.

Unit:5	**Performance Surfaces and Performance Optimizations**	**12 hours**

Directional Derivatives - Minima-Necessary Conditions for Optimality-Quadratic Functions-Performance Optimizations-Steepest Descent-Newton’s Method-Conjugate Gradient.

	Total Lecture hours	**6 0 hours**

Text Book(s)

Martin T. Hagan, Howard B. Demuth and Mark Beale, Neural Network Design, Vikas Publishing House, New Delhi,2002.

Reference Books

	James A. Freeman, David M. Skapura, Neural Networks Algorithms, Applications and Programming Techniques, Pearson Education, 2003.
	Robert J. Schalkoff, Artificial Neural Network, McGraw-Hill International Edition, 1997.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
	https://nptel.ac.in/courses/117/105/117105084/
	https://nptel.ac.in/courses/106/106/106106184/

Mapping with Programme Outcomes										
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**S**	**L**	**M**	**M**	**M**	**L**	**M**	**S**	**S**	**M**
CO2	**S**	**M**	**M**	**L**	**L**	**L**	**L**	**M**	**M**	**M**
CO3	**L**	**M**	**M**	**S**	**L**	**L**	**L**	**M**	**M**	**M**
CO4	**M**	**M**	**L**	**L**	**M**	**L**	**L**	**L**	**M**	**S**
CO5	**M**	**M**	**M**	**L**	**L**	**L**	**L**	**S**	**M**	**M**

*S-Strong; M-Medium; L-Low

Course code		Skill Enhancement Course- NME-I: OFFICE AUTOMATION AND ICT TOOLS (PRACTICAL)	L	T	P	C
Semester-III			**2**	**0**	**2**	**2**

Course Objectives:

The main objectives of this course are to:

1. To learn about basic commands of MS Word, MS Excel and MS Access.

Expected Course Outcomes:

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

1	Acquire practical knowledge about MS-Word, MS-Excel,	K2, K3
2	Understand about MS-PowerPoint and Ms-Access.	K2
3	Apply mathematical symbols into MS-word and MS-Power point.	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

LIST OF PRACTICALS

MS Word:

1. Preparation of word document (Typing, aligning, Font Style, Font Size, Text editing, colouring, Spacing, Margins)
2. Creating and Editing a table (Select no of rows, Select no of columns, row heading, column heading, column width, row width, row height, spacing text editing)
3. Formatting a table (insert rows/columns, delete rows/columns, cell merging / splitting, Cell alignment)
4. Preparation of letters using mail merge.
5. Demonstration of Find, Replace, Cut, Copy and paste texts in a word document.

MS Excel:

6. Creation of Charts, Graphs and Diagrams.
7. Calculation of Measures of central Tendency 8. Calculation of Standard Deviation.

MS Power Point:

9. Preparation of slides in power point.
10. Creation of Animation Pictures.

MS Access:

11. Creation of simple reports using MS Access.

General

12. Create a Google meet link.
13. Create a Google form.

Text Book(s)	
1	Andy Channelle, Beginning Open Office 3: From Novice to Professional, A Press series, Springer-Verlog, 2009.
Reference Books	
1	Perry M. Greg, Sams Teach Yourself Open Office.org All In One, Sams Publications, 2007.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	M	M	M	L	L	M	M
CO2	M	L	L	M	M	M	L	L	M	M
CO3	L	M	L	M	M	S	L	S	S	M
CO4	M	L	L	M	M	M	L	L	M	M
CO5	L	M	M	M	M	S	L	S	S	M

*S-Strong; M-Medium; L-Low

Course code		Core Paper VII: COMPLEX ANALYSIS	L	T	P	C
Semester-III			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. Define and recognize the basic properties of the complex numbers
2. Enable the students to the differentiability of complex functions and the results related on the study.
3. Study Cauchy's integral formula, local properties of analytic functions, general form of Cauchy's theorem and evaluation of definite integral.

Expected Course Outcomes:

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

1	Remembering the concept of Analytic function and as a mapping on the plane.	K1
2	Understand Cauchy's Integral Formula on open sets on the plane and know about poles , residues and singularities.	K2
3	Apply the Cauchy's integral formula in residue theorems and in evaluation of definite integrals.	K3, K4
4	Analyze and represent the sum function of a power series as an Analytic Function.	K5
5	Study and Understand periodic function, Weierstrass $\wp$ function and its applications.	K2, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Complex Integration and Cauchy's Integral Formula	18 hours

Fundamental Theorems: Line Integrals – Rectifiable Arcs - Line Integrals as Functions of Arcs– Cauchy's Theorem for a Rectangle – Cauchy's Theorem in a Disk - Cauchy's Integral formula: The index of a point with respect to a closed curve – The Integral formula – Higher derivatives.

Unit:2	Local Properties of Analytic Functions	18 hours

Local Properties of Analytic Functions: Removable Singularities - Taylor's theorem – Zeros and poles – The Local Mapping – The Maximum principle.

Unit:3	The Calculus of Residues and Harmonic Functions	18 hours

The Calculus of Residues: The Residue theorem – The Argument Principle – Evaluation of Definite Integrals - Harmonic functions: Definitions and Basic Properties – The Mean - value Property – Poisson's formula – Schwarz's Theorem.

Unit:4	Series and Product Developments, Partial fractions and Factorization	18 hours

Power Series Expansions: Weierstrass's Theorem – The Taylor Series – The Laurent Series - Partial fractions and Factorization: Partial Fractions – Infinite Products.

Unit:5	**Canonical Products**	**18 hours**
Canonical Products – The Riemann Mapping theorem : Statement and Proof - The Schwarz – Christoffel Formula – A closer look at harmonic functions: Functions with Mean -value Property - Harnack's Principle.		
	Total Lecture hours	**90 hours**

Text Book(s)

1	L. V. Ahlfors, Complex Analysis, McGraw Hill Education (India) Pvt. Ltd, 2013,. UNITI: Chapter4 : Sections 1.1 –1.5 Chapter4 : Sections 2.1 – 2.3, 3.1, 3.2 and3.4 UNITII: Chapter4 : Sections 3.1 – 3.4 UNITIII: Chapter4 : Sections 5.1 – 5.3, 6.1 –6.4 UNITIV: Chapter5 : Sections 1.1 – 1.3, 2.1, 2.2 UNITV: Chapter5 : Section 2.3 Chapter6 : Sections 1.1, 2.2,3.1,3.2

Reference Books

1	S. Ponnusamy and H. Silverman, A Complex Variable with applications, Birkhauser, Boston, 2006.
2	Karunakaran V, Complex Analysis, Narosa Publishing House Pvt. Ltd, Second Edition, New Delhi, 2006.
3	Roopkumar R, Complex Analysis, Dorling Kinderley Pvt. Ltd, New Delhi, 2015.

Mapping with Programme Outcomes

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	L	L	M	M	M	L	M
CO2	M	S	M	L	M	M	M	M	L	M
CO3	M	S	M	S	M	M	S	S	M	M
CO4	M	S	S	S	M	S	S	M	L	S
CO5	S	M	S	S	M	S	S	M	M	S

*S-Strong; M-Medium; L-Low

Course code		Core Paper VIII: PROBABILITY THEORY	L	T	P	C
Semester-III			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. To introduce axiomatic approach to probability theory, to study some statistical characteristics, discrete and continuous distribution functions and their properties, characteristic function and basic limit theorems of probability.

Expected Course Outcomes:

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

1	Remembering the understanding the basic concepts such as statistics, probability and random variables.	K1, K2
2	To solve Regression of the first and second types.	K5
3	To solve problems on Cauchy and Laplace distributions.	K5
4	To explain and solve problems on Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.	K2, K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Random Events and Random Variables	18 hours

Random events – Probability axioms – Combinatorial formulae – conditional probability – Bayes Theorem – Independent events – Random Variables – Distribution Function – Joint Distribution – Marginal Distribution – Conditional Distribution – Independent random variables – Functions of random variables. (**Chapter 1: Sections 1.1 to 1.7**, **Chapter 2 : Sections 2.1 to 2.9)**

Unit:2	Parameters of the Distribution	18 hours

Expectation- Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors – Regression of the first and second types. (**Chapter 3 : Sections 3.1 to 3.8)**

Unit:3	Characteristic functions	18 hours

Properties of characteristic functions – Characteristic functions and moments – semi0invariants – characteristic function of the sum of the independent random variables – Determination of distribution function by the Characteristic function – Characteristic function of multidimensional random vectors – Probability generating functions. (**Chapter 4 : Sections 4.1 to 4.7)**

Unit:4	Some Probability distributions	18 hours

One point , two point , Binomial – Polya – Hypergeometric – Poisson (discrete) distributions – Uniform – normal gamma – Beta – Cauchy and Laplace (continuous)distributions. **(Chapter 5 : Section 5.1 to 5.10)**

Unit:5	Limit Theorems	18 hours
Stochastic convergence – Bernaulli law of large numbers – Convergence of sequence of distribution functions – Levy-Cramer Theorems – de Moivre-Laplace Theorem – Poisson, Chebyshev, Khintchine Weak law of large numbers – Lindberg Theorem – LapunovTheroem – Borel-Cantelli Lemma - Kolmogorov Inequality and Kolmogorov Strong Law of large numbers. (**Chapter 6 : Sections 6.1 to 6.4, 6.6 to 6.9 , 6.11 and 6.12.)**		
	Total Lecture hours	**90 hours**

Text Book(s)

1	M. Fisz, *Probability Theory and Mathematical Statistics,* 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	R.Durrett, *Probability : Theory and Examples,* (2nd Edition) Duxbury Press, New York, 1996.
4	V.K.Rohatgi*An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd., New Delhi, 1988(3rd Print).
5	S.I.Resnick, *A Probability Path*, Birhauser, Berlin,1999.
6	B.R.Bhat , *Modern Probability Theory* (3rd Edition), New Age International (P)Ltd, New Delhi, 1999

Mapping with Programme Outcomes

Cos \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P
CO1	S	S	M	L	L	M	M	M	L	M
CO2	M	S	M	L	M	M	M	M	L	M
CO3	M	S	M	S	M	M	S	S	M	M
CO4	M	S	S	S	M	S	S	M	L	S
CO5	S	M	S	S	M	S	S	M	M	S

*S-Strong; M-Medium; L-Low

Course code		Core Paper IX: TOPOLOGY	L	T	P	C
Semester-III			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. To introduce the concepts of point-set topology with emphasis on continuous functions, homeomorphism ,connectedness, compactness, countability and separation axioms.

Expected Course Outcomes:

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

1	Acquire knowledge about various types of topological spaces and their properties	K4
2	Discuss connected spaces, the components of a space	K2
3	Apply the properties and derive the proofs of theorems.	K3
4	Construct a variety of examples and counter examples in topology	K6
5	Understand the properties of the compact spaces and analyse the different types of compactness.	K2, K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	**Topological Spaces and Continuous functions**	**18 hours**

Types of Topological Spaces and Examples - Basics for a topology - The order topology -The product topology on X x Y - The subspace topology - Closed sets and limits points - Continuous functions.

Unit:2	**Topological Spaces and Continuous functions (Contd) and Connectedness**	**18 hours**

The Product Topology - The metric topology - Sequence lemma- Uniform limit theorem- Connected spaces - Connected subspaces of the real line - Components and Local connectedness.

Unit:3	**Compactness**	**18 hours**

Compact spaces - Compact subspaces of the real line -Uniform continuity theorem - Limit Point Compactness – complete metric spaces –compactness in metricspaces.

Unit:4	**Countability and Separation Axioms**	**18 hours**

First and Second countable spaces - Lindeloff and Separable spaces - Countability axioms - The separation axioms - Normal spaces - The Uryshon’s lemma.

Unit:5	**Countability and Separation Axioms and Tychonoff Theorem**	**18 hours**

The UrysohnMetrization Theorem - Tietze Extension Theorem - The Tychonoff theorem – Stone Cechcompactifications.

	Total Lecture hours	**90 hours**

Text Book(s)

1	James R. Munkres, Topology, Second Edition, Prentice-Hall of India, New Delhi, 2006.
Reference Books	
1	G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill Edition, New Delhi, 2004.
2	Fred H. Croom, Principles of Topology, Cengage India Pvt Ltd, New Delhi, 2009.
3	Seymour Lipschutz, Schaum's Outline of Theory and Problems of General Topology, McGraw-Hill Edition, New Delhi, 2006.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/content/storage2/courses/111106054/Topology%20complete%20course.p df
2	https://www.youtube.com/watch?v=Oe3Qjk3t0go&lc=UghijV07WCAwpHgCoAEC
3	https://www.youtube.com/watch?v=2OMPmrHEO2M

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO**
CO1	**L**	**M**	**S**	**L**	**M**	**M**	**S**	**L**	**M**	**S**
CO2	**S**	**M**	**M**	**L**	**L**	**S**	**S**	**M**	**S**	**M**
CO3	**S**	**M**	**S**	**L**	**M**	**S**	**S**	**S**	**M**	**S**
CO4	**S**	**S**	**S**	**M**	**L**	**S**	**S**	**S**	**M**	**S**
CO5	**S**	**M**	**S**	**M**	**M**	**S**	**S**	**S**	**M**	**S**

*S-Strong; M-Medium; L-Low

Course code		**Core Paper X: MECHANICS**	**L**	**T**	**P**	**C**
Semester-III			**6**	**0**	**0**	**4**

Course Objectives:

The main objectives of this course are to:

1. understand the concepts of generalized coordinates, virtual work, Lagrange’s equations and Hamilton’s Principle. To discuss the applications of the above concepts with suitable examples.
2. Proficient in derivation and application of Hamilton-Jacobi equations 3. gain knowledge about canonical transformations, Lagrange and Poisson brackets

Expected Course Outcomes:

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

1	Understand the basic concepts of the mechanical system, generalized coordinates, work, energy and momentum.	K2
2	Solve and analyze the Lagrange’s equations and integrals of motion with examples.	K4, K5
3	Understand the Hamilton’s Principle and other variational principles and gain	K2
4	Understand and develop the Hamilton’s Principal function and Hamilton	K6
5	Get familiar with canonical transformations, conditions of canonicity of a transformation in terms of Lagrange and Poisson brackets	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Introductory Concepts**	**18 hours**

Mechanical system – Generalized Coordinates – Constraints – Virtual Work – Energy and Momentum.

Unit:2	**Lagrange’s Equations**	**18 hours**

Derivations of Lagrange’s Equations: Derivations of Lagrange’s Equations – Examples – Integrals of Motion.

Unit:3	**Hamilton’s Equations**	**18 hours**

Hamilton’s Principle – Hamilton’s Equations.

Unit:4	**Hamilton – Jacobi Theory**	**18 hours**

Hamilton’s Principle function – Hamilton – Jacobi Equation – Separability.

Unit:5	**Canonical Transformations**	**18 hours**

Differential forms and Generating Functions – Lagrange and Poisson Brackets.

	Total Lecture hours	**90 hours**

Text Book(s)	
1	D. T. Greenwood, Classical Dynamics, Dover Publications, New York, 1997. Unit-I: Chapter 1: Sections 1.1 – 1.5 Unit-II: Chapter 2: Sections 2.1 – 2.3 Unit-III: Chapter 4: Sections 4.1 – 4.2 Unit-IV: Chapter 5: Sections 5.1 – 5.3 Unit-V: Chapter 6: Sections 6.1, 6.3
Reference Books	
1	F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975.
2	I. M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice-Hall of India, New Delhi, 1963.
3	S. L. Loney, An Elementary Treatise on Statics, Kalyani Publishers, New Delhi, 1979.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	http://math.ucr.edu/home/baez/classical/texfiles/2005/book/classical.pdf.
2	https://nptel.ac.in/courses/115/103/115103115/
3	https://www.youtube.com/watch?v=G6OX1NpToaw

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	S	M	S	L	S	L
CO2	M	S	M	S	S	L	M	S	L	M
CO3	S	S	M	S	S	L	S	S	M	L
CO4	S	S	M	S	S	M	M	S	L	S
CO5	S	S	M	S	S	M	M	S	L	S

*S-Strong; M-Medium; L-Low

Course code		ELECTIVE-V- FLUID DYNAMICS	L	T	P	C
Semester-III			**3**	**0**	**0**	**3**

Course Objectives:

The main objectives of this course are to:

1. Able to know the fundamental concepts of fluids and its properties.
2. Develop the problems solving skill in fluid dynamics.
3. Know the real-life applications of fluid dynamics.

Expected Course Outcomes:

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

1	Recall the basic concepts of velocity, density and curvilinear co-ordinates.	K1
2	Understand the concepts and equations of fluid dynamics	K2
3	Analyze and understand the concepts of the force experienced by a two- dimensional fixed body in a steady irrotational flow.	K2, K4
4	Analyze the approximate solutions of the Navier – Stokes equation.	K4, K5
5	Analyze and apply the appropriate method to solve integral equation of boundary layer, Blasius equation and its series solution.	K3,K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Bernoulli's Equation and Equations of Motion**	**9 hours**

Introductory Notions – Velocity – Stream Lines and Path Lines – Stream Tubes and Filaments – Fluid Body – Density – Pressure. Differentiation with respect to the time – Kinematical and physical conditions – Rate of change of linear momentum – Equation of motion of an inviscid fluid.

Unit:2	**Equations of Motion (Contd)**	**9 hours**

Euler's momentum Theorem – Conservative forces – Bernoulli's theorem in steady motion – Kelvin's theorem – vortex motion – Helmholtz equation.

Unit:3	**Two-Dimensional Motion**	**9 hours**

Two Dimensional Motion – Two Dimensional Functions – Complex Potential – basic singularities – source – sink – Vortex – doublet – Circle theorem – Blasius Theorem – Lift force. (Magnus effect)

Unit:4	**Dynamics of Real Fluids**	**9 hours**

Viscous flows – Navier-Stokes equations – Vorticity and circulation in a viscous fluid – Steady flow through an arbitrary cylinder under pressure.

Unit:5	**The Laminar Boundary Layer in Incompressible Flow**	**9 hours**

Boundary Layer concept – Boundary Layer equations – Displacement thickness, Momentum thickness – Kinetic energy thickness– flow parallel to semi infinite flat plate – Blasius equation and its solution in series.

	Total Lecture hours	**45 hours**
Text Book(s)		
1	**Units I and II:** L. M. Milne Thomson, Theoretical Hydro Dynamics, Macmillan Company, 5th Edition (1968). Chapter I : Sections 1.0 – 1.3., 3.10, 3.30, 3.31, 3.40, 3.41. Chapter III : Sections 3.42, 3.43, 3.45, 3.52, 3.53	
2	**Units III, IV and V:** Modern Fluid Dynamics Volume I, N. Curle and H. J. Davies, D. Van Nostrand Company Limited., London, 1968. Chapter III : Sections 3.1-3.3, 3.5.1, 3.7.4, 3.7.5 Chapter V : Sections 5.2, 5.2.2, 5.2.3, 5.3.1 Chapter VI : Sections 6.1.1, 6.2, 6.2.3, 6.3.1,	
Reference Books		
1	F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers, New Delhi, 2004.	
2	A. J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics, Springer-Verlag, New York, 1993.	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://nptel.ac.in/courses/112/106/112106200/	
2	https://nptel.ac.in/courses/112/105/112105171/	

Mapping with Programme Outcomes										
COs POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO**
CO1	**M**	**S**	**M**	**M**	**M**	**L**	**L**	**M**	**M**	**S**
CO2	**M**	**S**	**M**	**M**	**S**	**M**	**S**	**M**	**M**	**S**
CO3	**L**	**M**	**M**	**M**	**S**	**M**	**S**	**S**	**M**	**S**
CO4	**M**	**M**	**S**	**S**	**M**	**M**	**S**	**S**	**M**	**S**
CO5	**L**	**M**	**S**	**M**	**M**	**M**	**S**	**S**	**M**	**S**

*S-Strong; M-Medium; L-Low

Course code		ELECTIVE-V- STOCHASTIC PROCESSES	L	T	P	C
Semester-III			3	0	0	3

Course Objectives:

The main objectives of this course are to:

1. Acquire knowledge about the concept of Markov Chain and Queueing System.
2. Understand the methods of Birth and Death queues with Finite and Infinite Capacity.
3. Develop the ability of Standard Brownian Motion.

Expected Course Outcomes:

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

1	Acquire adequate knowledge about Continuous Time Markov Chain and Queueing	K1
2	Gain understanding on the Renewal Process, Cumulative Process and SemiMarkov Process.	K2, K3
3	Apply different methods and solve Birth and Death queues.	K3
4	Examine the computations of M/G/1 and G/M/1 Queues and Network of Queues.	K5
5	Conclude the idea of Brownian Motion and First Passage Times.	K4, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Continuous-Time Markov Models	9 hours

Continuous Time Markov Chain, Examples, Transient Analysis, Occupancy Times, Limiting Behavior.

Unit:2	Generalized Markov Models	9 hours

Renewal Process, Cumulative Process, Semi-Markov Process, Examples and Long term Analysis.

Unit:3	Queueing Models	9 hours

Queueing Systems, Single-Station Queues, Birth and Death queues with Finite and Infinite Capacity.

Unit:4	Queueing Models (Contd)	9 hours

M/G/1 and G/M/1 Queues and Network of Queues.

Unit:5	Brownian Motion	9 hours

Standard Brownian Motion, Brownian Motion and First Passage Times.			
		Total Lecture hours	**45 hours**
Text Book(s)			
1	V. G. Kulkarni, Introduction to Modelling and Analysis of Stochastic Systems, Second Edition, Springer, 2011.		
Reference Books			
1	J. Medhi, Stochastic Processes, New Age, 2009.		
2	S. M. Ross, Stochastic Processes, Wiley Series in Probability and Statistics, 1996.		
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]			
1	https://nptel.ac.in/courses/111/102/111102014/#		
2	https://nptel.ac.in/courses/111/102/111102014/#		
3	https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2145&context=gradreports		

Mapping with Programme Outcomes										
COs POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO**
CO1	**M**	**S**	**M**	**M**	**M**	**L**	**L**	**M**	**M**	**S**
CO2	**M**	**S**	**M**	**M**	**S**	**M**	**S**	**M**	**M**	**S**
CO3	**L**	**M**	**M**	**M**	**S**	**M**	**S**	**S**	**M**	**S**
CO4	**M**	**M**	**S**	**S**	**M**	**M**	**S**	**S**	**M**	**S**
CO5	**L**	**M**	**S**	**M**	**M**	**M**	**S**	**S**	**M**	**S**

*S-Strong; M-Medium; L-Low

Course code		Skill Enhancement Course- NME 1: MATHEMATICAL DOCUMENTATION USING LATEX	L	T	P	C
Semester-III			**3**	**0**	**0**	**2**

Course Objectives:

The main objectives of this course are to:

1. Understand richness of Latex rather than using M.S word for documentation.
2. Proficient in documentation using mathematical symbols, graphs and tables.

Expected Course Outcomes:

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

1	Understand basic concepts of Text formatting and LaTex file	K2
2	Demonstrating command names and arguments, Special characters.	K3
3	Apply the commands to create document layout and displayed output	K3, K6
4	Create Table, Printing Text, Foot notes and marginal notes	K6
5	Apply LaTex commands to mathematical formulae	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Introduction**	**9 hours**

Text formatting, TEX and its offspring, What's different in LATEX 2є, Distinguishing LaTex 2є, Basics of a LaTex file.

Unit:2	**Commands and Environments**	**9 hours**

Command names and arguments, Environments, Declarations, Lengths, Special Characters – Spaces and carriage returns, Quotation marks, Hyphens and dashes, Printing command characters, The date, Exercises.

Unit:3	**Document Layout and Organization**	**9 hours**

Document class, Page style, Parts of the document, Table of contents – Automatic entries, Printing the table of contents, Fine-Tuning text – Line breaking, Page breaking.

Unit:4	**Displayed Text**	**9 hours**

Displayed Text – Changing font – Emphasis, Choice of font size, Font attributes, Centering and indenting, Lists. Tables, Printing literal text, Footnotes and marginal notes.

Unit:5	**Mathematical Formulae**	**9 hours**

Mathematical environments, Main elements of math mode, Mathematical symbols – Greek letters, function names, Additional elements, Fine–tuning mathematics – Horizontal spacing, Selecting font size in formulas.

	Total Lecture hours	**45 hours**

Text Book(s)

1	Helmut Kopka and Patrick W. Daly, A Guide to LATEX, Third Edition, Addison – Wesley, London,1999. Unit I : Chapter 1 : Sections : 1.1-1.3, 1.4.1, 1.5. Unit II : Chapter 2 : Sections : 2.1-2.4, 2.5.1-2.5.4, 2.5.9, 2.7. Unit III : Chapter 3 : Sections : 3.1-3.3, 3.4.1, 3.4.2, 3.5.2, 3.5.5, Chapter 4 : 4.1.1-4.1.3, 4.2, 4.3 Unit IV : Chapter 4 : Sections : 4.8-4.10. Unit V : Chapter 5: Sections : 5.1, 5.2, 5.31, 5.3.8, 5.4, 5.4.1 – 5.4.8, 5.5.1, 5.5.2.

Reference Books

1	VelusamyKavitha and Mani Mallikarjunan, Fundamentals of Latex for Mathematicians, Physicists and Engineers, LAP LAMBERT Academy Publishing,

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://www.youtube.com/watch?v=Q4FozDTRE_4
2	https://www.youtube.com/watch?v=DvDO1mea1w0

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	M	M	M	L	L	M	M
CO2	M	L	L	M	M	M	L	L	M	M
CO3	L	M	L	M	M	S	L	S	S	M
CO4	M	L	L	M	M	M	L	L	M	M
CO5	L	M	M	M	M	S	L	S	S	M

*S-Strong; M-Medium; L-Low

Course code		Core Paper XI:**FUNCTIONAL ANALYSIS**	**L**	**T**	**P**	**C**
Semester-IV			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. To get an overview of normed spaces and familiarize on Banach space, Hilbert space , conjugate space ,bounded linear operators and spectral theory.

Expected Course Outcomes:

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

1	Familiarize with the concepts of normed linear spaces and operators on normed linear space	K1
2	Demonstrate an understanding of the concepts of Hilbert spaces and Banach spaces, and their role in mathematics	K2
3	Apply the theorems.	K3
4	Obtain Orthogonal complements, Orthonormal sets and conjugate space.	K4
5	Understand the concepts of linear operators, self adjoint, unitary operators , isometric isomorphism on Hilbert spaces ,Determinants ,the spectrum of an operator, Banach algebra.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Banach**	**18 hours**

Banach spaces – The definition and some examples – Continuous linear transformations – The Hahn-Banach theorem –Dual spaces- The natural imbedding of N in N** - The open mapping theorem - Closed Graph theorem.

Unit:2	**Hilbert**	**18 hours**

The conjugate of an operator – Uniform boundedness Principal - Hilbert spaces – The definition and some simple properties – Orthogonal complements and complements - Orthonormal sets and sequences – Maximal Orthonormal sets.

Unit:3	**Hilbert spaces (Contd)**	**18 hours**

The Conjugate space H* - Representation of functional on Hilbert spaces -The adjoint of an operator – Self-adjoint operators – Normal and unitary operators – Projections.

Unit:4	**Finite-Dimensional Spectral Theory**	**18 hours**

Matrices – Determinants and the spectrum of bounded operator – The spectral theorem.

Unit:5	**General Preliminaries on Banach Algebras**	**18 hours**

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

	Total Lecture hours	**90 hours**

Text Book(s)	
1	G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, London, 1963. UnitI: Sections: 46 –50. UnitII: Sections: 51 –54. UnitIII: Sections: 55 –59. UnitIV: Sections: 60 –63. UnitV: Sections: 64 –68.
Reference Books	
1	C. Goffman and G. Pedrick, A First Course in Functional Analysis, Prentice Hall of India, New Deli, 1987.
2	G. Bachman and L. Narici, Functional Analysis, Academic Press, New York, 1966.
3	L. A. Lusternik and V.J. Sobolev, Elements of Functional Analysis, Hindustan Publishing Corporation, New Delhi, 1971.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/105/111105037/
2	https://ocw.mit.edu/courses/mathematics/18-102-introduction-to-functional-analysis-spring- 2009/lecture-notes/

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	S	L	M	S
CO2	S	S	M	M	L	S	S	M	S	M
CO3	M	M	L	S	S	S	S	S	M	S
CO4	S	M	S	L	L	S	S	S	M	S
CO5	S	S	S	L	M	S	S	M	S	M

*S-Strong; M-Medium; L-Low

Course		Core Paper XII:DIFFERENTIAL GEOMETRY	L	T	P	C
Semester-IV			**6**	**0**	**0**	**5**

Course Objectives

The main objectives of this course are to:

1. Gain knowledge about curves and its characterizations.
2. Get sufficient knowledge on Elementary Theory of surfaces.
3. Make the students to familiarize with space curves and curves on surfaces.

Expected Course Outcomes:

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

1	Define and understand basic definitions of the theory of curves.	K1
2	Interpret the notions of surface of revolution and direction coefficients.	K2
3	Analyze the elements of Analytic representation.	K4
4	Acquire knowledge on first fundamental form and second fundamental form.	K4
5	Explain Meusnier's theorem and Euler's Theorem on elementary theory of	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	**Representation and Theory of Space Curves**	**18 hours**

Representation and theory of Space Curves introduction-Representation of space curves-Unique parametric representation of a space curve- Arc length - tangent and osculating plane - principal normal and binormal - curvature and torsion - contact between curves and surfaces - osculating circle and osculating sphere - locus of centres of spherical curvature.

Unit:2	**Evolutes of a Plane and Space Curve**	**18 hours**

Evolutes of a Plane and Space Curve introduction- Tangent surfaces - Involutes and evolutesBetrand curves - Spherical indicatrix - Intrinsic equations of space curves – Fundamental existence theorem for space curves - Helices.

Unit:3	**The First Fundamental Form and Local Intrinsic Properties of a Surface**	**18 hours**

The First Fundamental Form and Local Intrinsic Properties of a Surface introduction- Definition of a surface - Nature of points on a surface - Representation of a surface - Curves on surfaces - Tangent plane and surface normal - The general surfaces of revolution – Helicoids - Metric on a surface - The first fundamental form - Direction coefficients on a surface.

Unit:4	**Families of curves**	**18 hours**

Families of curves introduction-- Orthogonal trajectories - Double family of curves – Isometric correspondence - Intrinsic properties - Geodesics on a surface: Geodesics and their differential equations - Canonical geodesic equations - Geodesics on surface of revolution - Normal property of geodesics - Differential equations of geodesics using normal property.

Unit:5	Existence Theorems	18 hours
Existence theorems proof- Geodesic parallels - Geodesic polar coordinates – Geodesic curvature - Gauss-bonnet theorem-Meusnieu"s theorem-Gaussian curvature Euler"s theorem-Duplin"s indicarix-Surface of revolution conjugate system-Asymmetric lines-isometric lines		
	Total Lecture hours	**90 hours**

Text Book(s)

1	**D. Somasundaram,** "Differential Geometry: A first course", Narosa Publishing House, New - Delhi, India, 2005. Unit I: Sections 1.2-1.7, 1.10-1.12 Unit II: Sections 1.13-1.18 Unit III: Sections 2.2-2.10 Unit IV: Sections 2.11-2.15, 3.2-3.6 Unit V: Sections 3.7-3.12

Reference Books

1	Differential Geometry by T.J. Willmore, Oxford University Press (Seventeenth Impression - 2002).
2	**Dirk J. Struik:** "Lectures on Classical Differential Geometry" (second edition),Addison Wesley PublishingCompany.
3	**J. N. Sharma & A. R. Vasistha**, "Differential Geormetry", KedarNath Ram Nath, Meerut, 1998.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/noc/courses/noc16/SEM2/noc16-ma07/
2	https://www.youtube.com/watch?v=tKnBj7B2PSg
3	http://pages.uoregon.edu/koch/math433/Final.pdf

Mapping with Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	**S**	**M**	**M**	**S**	**S**	**L**	**S**	**S**	**L**	**M**
CO2	**M**	**S**	**M**	**M**	**M**	**M**	**M**	**L**	**M**	**S**
CO3	**S**	**M**	**S**	**M**	**L**	**M**	**S**	**M**	**S**	**L**
CO4	**M**	**S**	**L**	**S**	**S**	**L**	**M**	**S**	**M**	**S**
CO5	**M**	**S**	**M**	**S**	**M**	**M**	**S**	**M**	**S**	**M**

*S-Strong; M-Medium; L-Low

Course code		Core Paper XIII: Project	L	T	P	C
Semester-IV			**10**	**0**	**0**	**7**

Course Objectives:

The main objectives of this course are to:

1. To study the basic concepts related to the Project work.
2. To know the respective research fields
3. To know the concept of writing a dissertation in an effectiveway.

Expected Course Outcomes:

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

1	Applying the relative notions in the respective areas and finding the results	K3
2	Analyzing results with the existing results.	K4
3	Interpreting the results with suitable examples.	K4
4	Acquire knowledge in their area of interest.	K2
5	Promote techniques of research	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Title of the Course	**PROJECT WITH VIVA VOCE-CC**						
Paper Number							
Category	Core	**Year**	II	**Credits**	7	**Course Code**	
		Semester	IV				
Instructional Hours per week	**Lecture**		**Tutorial**		**Lab Practice**	**Total**	
	10				--	10	

Course code		ELECTIVE-VI-: MATHEMATICAL PYTHON	L	T	P	C
Semester-IV			**2**	**0**	**0**	**3**

Course Objectives:

The main objectives of this course are to:

1. To introduce the fundamentals of Python Programming.
2. To teach about the concept of Functions inPython.
3. To impart the knowledge of Lists, Tuples, Files and Directories

Expected Course Outcomes:

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

1	Remembering the concept of operators, data types, Loops and control statements in Python programming.	K1
2	Understanding the concepts of Input / Output operations in file.	K2
3	Applying the concept of functions and exception handling	K3
4	Analyzing the structures of list, tuples and maintaining dictionaries.	K4
5	Applying the concept of User defined exceptions	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Introduction to Python**	**6 hours**

Introduction - Python Overview - Getting Started with Python – Comments - Python Identifiers - Reserved Keywords – Variables - Standard Data Types. Operators - Statement and Expression - String Operations - Boolean Expressions - Control Statements - Iteration - While Statement - Input from Keyboard.

Unit:2	**Functions**	**6 hours**

Built-in functions - Composition of functions - User defined functions - Parameters and Arguments - Function Calls - The return Statement - Python Recursive Function - The Anonymous Functions – Writing Python Scripts.

Unit:3	**Strings and Lists**	**6 hours**

Strings**:** Compound Data Type - Len Function - String Slices - Strings are Immutable - String Traversal - Escape Characters - String Formatting Operator - String Formatting Functions. Values and Accessing Elements - Lists are Mutable - Deleting Elements from List- Built-in list Operators - Built-in List Methods.

Unit:4	**Dictionaries**	**6 hours**

Dictionaries: Creating a Dictionary - Accessing values in a Dictionary - Updating Dictionary - Deleting elements from Dictionary - Properties of Dictionary keys - Operations in Dictionary - Built- in Dictionary methods.

Unit:5	**Files**	**6 hours**

Files: Text files: Opening a file - Closing a file - The file object attributes - Writing to a file - Reading from a file - Renaming a file - Deleting a file - Files related methods.

* - Self Study and questions for examinations may be taken from the self study portions also.

		Total Lecture hours	30 hours

Text Book(s)

1	E. Balagurusamy, Problem Solving and Python Programming, First Edition , 2017, McGraw-Hill Education (India) Pvt. Ltd, Chennai.

Reference Books

1	1. Ashok Namdev Kamthane,Amit Ashok Kamthane, Programming and Problem Solving with Python, McGraw-Hill, First Edition,2017.
2	2. Martin Jones, Python for Complete Beginners, Create space Independent Publisher, First Edition, 2015.
3	3. S.A Pv. Kulkarni, Problem Solving and Python Programming, Yes Dee Publishing t.Ltd, First Edition, 2017.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	S	L	M	S
CO2	S	S	M	M	L	S	S	M	S	M
CO3	M	M	L	S	S	S	S	S	M	S
CO4	S	M	S	L	L	S	S	S	M	S
CO5	S	S	S	L	M	S	S	M	S	M

*S-Strong; M-Medium; L-Low

<table>
<tr><td>Course code</td><td></td><td>Core Practical-I: Programming in Python - Practical</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">Semester-IV</td><td></td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td colspan="7">The main objectives of this course are to:
1. To gain knowledge about the concepts of Python programming.
2. To solve algebraic and non-linear ordinary differential equations using Python programs.
3. To enhance the students to develop the program writing skills for mathematical problems.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Expected Course Outcomes:</td></tr>
<tr><td colspan="7">On the successful completion of the course, student will be able to:</td></tr>
<tr><td>1</td><td colspan="2">Understand the concept of Python programming</td><td colspan="4">K2</td></tr>
<tr><td>2</td><td colspan="2">Utilizing Python program for finding the Numerical solutions of Algebraic and Transcendental Equations.</td><td colspan="4">K3</td></tr>
<tr><td>3</td><td colspan="2">Analyzing the GCD, interpolation values and File management using Python programs</td><td colspan="4">K4</td></tr>
<tr><td>4</td><td colspan="2">Implement basic operators and function concepts.</td><td colspan="4">K5</td></tr>
<tr><td>5</td><td colspan="2">Applying, compiling and debugging programs with the help of Python</td><td colspan="4">K6</td></tr>
</table>

LIST OF PRACTICAL PROGRAMS

1. Program to determine the Greatest Common Divisor (GCD) of any two integers.
2. Program to accept two complex numbers and find their sum.
3. Program to display the Pascal's triangle.
4. Program to find the number of instances of different digits in a given number.
5. Program to find the number of vowels and consonants in a text string.
6. Program to find the numerical solution of algebraic and transcendental equations by using
   (i) Bisection Method.
   (ii) Newton Raphson Method.
7. Program to solve an ordinary differential equation by using Fourth order Runge-Kutta Method.
8. Program to find the interpolation value using Lagrange's method.
9. Program to solve the simultaneous equations by
   (i) Gauss Elimination Method
   (ii) Gauss Seidel Method
10. Program to demonstrate File Input and Output operations.

COs/POs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S	S	S	S	S	S	S	S	S	S
CO2	S	S	S	M	S	S	S	S	M	S
CO3	S	S	S	S	S	S	M	S	S	S
CO4	S	S	M	S	S	S	S	M	S	S
CO5	S	S	S	S	M	S	S	S	M	S

S- Strong = 3, M-Medium= 2, L-Low = 1

Course code		**ELECTIVE-VI: FINANCIAL MATHEMATICS**	**L**	**T**	**P**	**C**
Semester-IV			**4**	**0**	**0**	**3**

Course Objectives:

In this course, the students are on posed to:

1. The basic concepts of Probability theory, The Central limit theorem.
2. The concepts of Geometric Brownian motion, Option pricing.
3. The derivatives of Blackschole formula and its applications.
4. The concept of call option on Dividend paying securities, estimating the volatility parameter.
5. The limitations of Arbitrage pricing, the portfolio selection problem.

Expected Course Outcomes:

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

1	To understand the basic concepts of Financial Mathematics.	K2
2	To understand and prove theorems.	K2, K5
3	To understand the method to solve the problems by applying principles and concepts of Financial Mathematics	K3, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Probability and Event**	**12 hours**

Probabilities and Events-Conditional Probability- -Random Variables and Expected Values-Covariance and Correlation-Continuous Random Variables-Normal Random Variables –Properties of Normal Random Variables- The Central Limit Theorem-Simple Problems. Section (1.1 - 1.4, 2.1 - 2.4)

Unit:2	**Geometric Brownian Motion and Pricing**	**12 hours**

Geometric Brownian Motion-Geometric Brownian Motion as a limit of Simple Models Brownian Motion-Simple Problems- Interest Rates – Present Value Analysis- Rate of Return Continuously Varying Interest Rates-An example of option Pricing –Other example of Pricing via Arbitrage. Section (3.1 - 3.3, 4.1 - 4.4, 5.1, 5.2)

Unit:3	**Black Scholes Formula and Derivation**	**12 hours**

The Arbitrage Theorem-The Multi period Binomial Model-Proof of the Arbitrage Theorem-The Black Scholes Formula-Properties of the Black –Sholes Option Cost-Derivation of Black Scholes Formula-Simple Problems. Section (6.1 - 6.3, 7.2, 7.3, 7.5)

Unit:4	**Volatility Parameter**	**12 hours**

Additional results on options- Call option on Divided Paying Securities-Pricing American Put Options-Adding Jumps to Geometric Brownian Motion-Estimating the Volatility Parameter- Simple Problems. Section (8.2 - 8.5)

Unit:5	Period and Geometric Brownian Motion	12 hours
Valuing by Expected Utility-Limitation of Arbitrage pricing-Valuing Investments by Expected Utility-The portfolio selection problem—Value at risk and conditional value at risk The capital assets pricing model-Mean Variances analysis of risk-Neutral priced Call optionsRates of return-Single Period and Geometric Brownian Motion-- Simple Problems. Section (9.1 - 9.7)		

	Total Lecture hours	**60 hours**

Text Book(s)

1	Sheldon M.Ross, An Elementary Introduction to Mathematical Finance,2nd Edition, Cambridge University press, 2005.

Reference Books

1	S.M.Ross, A First Course in Probability, Englewood cliffs Prentice HallNJ, 2002.
2	J.Cox M.Rubinstein, Option Market, Englewood cliffs Prentice HallNJ, 1985.
3	J.E.Ingersill, Theory of Financial decision Making, Lanjarn MD Rowerman of Little Fields, 1987.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	**S**	**S**	**S**	**M**	**M**	**M**	**S**	**L**	**M**	**S**
CO2	**S**	**S**	**M**	**M**	**L**	**S**	**S**	**M**	**S**	**M**
CO3	**M**	**M**	**L**	**S**	**S**	**S**	**S**	**S**	**M**	**S**
CO4	**S**	**M**	**S**	**L**	**L**	**S**	**S**	**S**	**M**	**S**
CO5	**S**	**S**	**S**	**L**	**M**	**S**	**S**	**M**	**S**	**M**

*S-Strong; M-Medium; L-Low

Course code		**Professional Competency Skill Enhancement Course- III**	**L**	**T**	**P**	**C**
Semester-IV		**Training for Competitive Examinations - Mathematics for NET / UGC –CSIR / SET / TRB Competitive Examinations and General Studies for UPSC/ TNPSC**	**4**	**0**	**0**	**4**

Mathematics for NET / UGC –CSIR / SET / TRB Competitive Examinations

Course Objectives:

In this course, the students are on posed to:

1. The basic concepts of differential equations.
2. The concepts of graph theory and their applications.
3. Solve the CR equation problems in complex analysis.
4. Solve the sampling problems.

Expected Course Outcomes:

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

1	To understand the basic concepts of differential and graph theory.	K2
2	To understand and prove theorems.	K2, K5
3	To understand the method to solve the problems by applying principles and concepts of complex, differential areas.	K3, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Linear Algebra**	**6 hours**

Theory of sets - Vector space – Inner product spaces – Theory of matrices.

Unit:2	**ComplexAnalysis**	**6 hours**

Introduction to the concept of analytic function - limits and continuity - analytic functions - Maclaurin’s series - Analytic functions - Cauchy’s theorem - Cauchy’s integral formula - higher derivatives - Local properties of Analytic functions and removable singularities- Taylor’s theorem - Zeros and Poles

Unit:3	**Graph Theory**	**6 hours**

Graphs and subgraphs: Graphs and simple graphs – Graph isomorphism - Incidence and adjacency matrices – Subgraphs – Vertex degrees – Path and cycles – Applications : path problem - Trees – Cut edges and bonds - Cut vertices – Connectivity – Blocks – Euler tours and Hamilton cycles- Matchings.

Unit:4	**Differential Equations**	**6 hours**

Types of differential equation –order and degree- variable separable- linear differential equation – integrating factor- linear equation of 2^{nd} order with constant coefficient – Exact differential equation

Unit:5	**Statistics**	**6 hours**
Probability Discrete - sample space, events - their union – intersection - Probability in continuous probability space - conditional probability and independence – Baye's theorem - probability functions - Probability density functions - Distribution function.		

	Total Lecture hours	**30 hours**

Text Book(s)

1	Arihant, NTA CSIR UGC, NET/SET, Mathematical Sciences.

General Studies for UPSC/ TNPSC

Course Objectives:

In this course, the students are on posed to:

1. The basic concepts of general mathematics.

Expected Course Outcomes:

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

1	To understand the basic concepts of statistics	K2
2	To understand and solve the probability problems.	K2, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**Measure of central tendency**	**6 hours**
Arithmetic mean - median - mode - geometric mean- Harmonic mean		

Unit:2	**Probability**	**6 hours**
Probability - Addition, Multiplication and Baye's Theorems and their application.		

Unit:3	**Distribution**	**6 hours**
Probability distributions – Marginal and conditional distributions – Expectations – Moments and cumulants generating functions.		

Unit:4	**Continuous Distribution**	**6 hours**
Probability distributions – Binomial, Poisson, Continuous distributions normal.		

Unit:5	**Measure of dispersion**	**6 hours**
Range - Quartaile - Mean Deviation - standard Deviation		

	Total Lecture hours	**30 hours**

Text Book(s)

1	B. L. Aggarwal, Basic statistics for competitive examinations.