ARULMIGU PALANIANDAVAR ARTS COLLEGE FOR WOMEN,

PALANI.

(Autonomous)

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

M.Sc., MATHEMATICS

SYLLABUS TO BE IMPLEMENTED FROM THE ACADEMIC YEAR 2022-2025

(CHOICE BASED CREDIT SYSTEM)

DEPARTMENT OF MATHEMATICS
M.SC. MATHEMATICS
SYLLABUS
BATCH: 2022-2025

FACULTY MEMBERS OF MATHEMATICS DEPARTMENT

Dr. K, Meena M.Sc.,M.Phil., PGDCA., Ph.D. Assistant Professor and Head
Dr.V.P.AnujaM.Sc.,M.Phil.,Ph.DAssistant Professor
Dr.R.Vasanthi M.Sc.,M.Phil., B.Ed., PGDCA., Ph.D., Assistant Professor

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.

DEPARTMENT OF MATHEMATICS

Choice Based Credit System(CBCS)

(2022-2023 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 thecountry

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 PGProgramme

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 respectivesubjects.

ii. **Mediumof Instruction:** English

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

- **EvaluationPattern**

Evaluation Pattern	Theory		Practical	
	Min	**Max**	**Min**	**Max**
Internal	**13**	**25**	**20**	**40**
External	**38**	**75**	**30**	**60**

- **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	
Practical			
CIA Practical		25	40
Observation Notebook		10	
Attendance		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**	**6*1 Marks=6**Multiple Choice Questions Q.No.1 to 6	**6**
2	**B**	**2*4 Marks=8** (Either or Pattern) Q.No. 7 and 8	**8**

3	**C**	**2*8 Marks=16** (Either or Pattern) Q.No. 9 and 10	**16**
Total Marks			**30**

- **Question Paper Pattern for External examination for all coursepapers.**

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

S.No.	Part	Type	Marks
1	**A**	**10*1 Marks=10** Multiple Choice Questions (MCQs): Two questions from each Unit	**10**
2	**B**	**5*7=35** Two questions from each Unit with Internal Choice (either / or)	**35**
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: 90**

- **ProjectReport**

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.

- **ProjectEvaluation**

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**

3. Conversion of Marks to Grade Points and Letter Grade (Performance in aCourse/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 OtherInformation

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

DEPARTMENT OF MATHEMATICS

M.Sc. Mathematics

(For the students admitted during the academic year 2022 – 2023 onwards)

S.No.	Course Code	Title of the Course	Credits	Hour		Maximum Marks		
				Theory	Practical	CIA	ESE	Total
	FIRST SEMESTER							
1		Core Paper I:Abstract Algebra	**5**	**6**	**–**	**25**	**75**	**100**
2		Core Paper II: Real Analysis	**5**	**6**	**–**	**25**	**75**	**100**
3		Core Paper III: Ordinary Differential Equations	**5**	**6**	**–**	**25**	**75**	**100**
4		Core Paper IV: Computer Oriented Numerical Methods	**5**	**6**	**–**	**25**	**75**	**100**
5		Elective-I Graph Theory / Neural Networks	**4**	**6**	**–**	**25**	**75**	**100**
		Total	**24**	**30**	**-**	**125**	**375**	**500**
	SECOND SEMESTER							
6		Core Paper V: Linear Algebra	**5**	**6**	**–**	**25**	**75**	**100**
7		Core Paper VI: Complex Analysis	**5**	**6**	**–**	**25**	**75**	**100**
8		Core Paper VII: Partial Differential Equations	**5**	**6**	**–**	**25**	**75**	**100**
9		Core Paper VIII: Optimization Techniques	**5**	**6**	**–**	**25**	**75**	**100**
10		Elective-II : Fuzzy Logic and Fuzzy sets / Magnetohydrodynamics	**4**	**6**	**–**	**25**	**75**	**100**
		Total	**24**	**30**	**-**	**125**	**375**	**500**
	THIRD SEMESTER							
11		Core Paper IX: Topology	**5**	**6**	**–**	**25**	**75**	**100**

12		Core Paper X: Fluid Dynamics	**5**	**6**		**25**	**75**	**100**
13		Core Paper XI: Differential Geometry	**4**	**6**	**–**	**25**	**75**	**100**
14		Core Paper XII: Programming in Python - Theory	**4**	**4**	**–**	**25**	**75**	**100**
15		Core Practical-I: Programming in Python - Practical	**2**	**-**	**2**	**40**	**60**	**100**
16		Elective III: Mathematical Statistics / Number Theory	**4**	**6**	**-**	**25**	**75**	**100**
		Total	**24**	**28**	**2**	**150**	**450**	**600**
	FOURTH SEMESTER							
17		Core Paper XIII: Functional Analysis	**5**	**6**	**–**	**25**	**75**	**100**
18		Core Paper XIV: Measure Theory	**5**	**6**	**–**	**25**	**75**	**100**
19		Elective-IV Elements of Stochastic Process / Control theory	**4**	**6**	**–**	**25**	**75**	**100**
20		Core Paper XV: Project	**4**	**12**	**-**	**25**	**75**	**100**
		Total	**18**	**30**	**-**	**100**	**300**	**400**
		Grand Total	**90**	**116**	**4**	**500**	**1500**	**2000**

Note:

CIA – ContinuousInternalAssessment

ESE – End of SemesterExaminations

Course code		Core Paper I: ABSTRACT ALGEBRA	L	T	P	C
Semester-I			6	0	0	5

Course Objectives:

The main objectives of this course are to:

1. To provide deep knowledge about various algebraicstructures.
2. To introduce Galois Theory and to see its application to the solvability ofpolynomial equations byradicals.

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	18hours

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	18hours

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

Unit:3	Ring Theory (contd) and Fields	18hours

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

Unit:4	Fields (contd)	18hours

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**	**18hours**
Solvability by radicals: Solvable group – the commutator subgroup – Solvability by radicals - Finite fields.		
	Total Lecture hours	**90hours**

Text Book(s)	
1	I.N. Herstein, Topics in Algebra, Secnd Edition, John Wiley and Sons, New York, 1975. UNITI: Chapter2 : Sections 2.11,2.12 UNITII: Chapter2 : Section2.13 Chapter3 : Sections 3.7-3.9 UNITIII: 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.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/content/storage2/111/106/111106113/MP4/mod08lec44.mp4
2	https://nptel.ac.in/content/storage2/111/106/111106113/MP4/mod08lec45.mp4
3	https://nptel.ac.in/content/storage2/111/106/111106131/MP4/mod08lec39.mp4
4	https://nptel.ac.in/content/storage2/111/106/111106131/MP4/mod08lec42.mp4

Mapping with Programme Outcomes

COs POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
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**	**L**	**T**	**P**	**C**
Semester-I			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. To convey concepts of real valued functions indetail.
2. To provide the deep knowledge about sequences andseries.
3. To make a clear difference between differentiability andcontinuity
4. To know some basictheorems**.**

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	**18hours**

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-Weierstrasstheorem

Unit:2	Perfect sets	**18hours**

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

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Unit:3	Power series	**18hours**

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:	**18hours**

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**	**18hours**

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	**90hours**

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 ", 2nd 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	5

Course Objectives:

The main objectives of this course are to:

1. Study Solutions of Linear differential equations with constant and variablecoefficients.
2. Understand and able to apply various theoretical ideas that underlined in existenceand uniqueness theorems, Linear independence and dependence, Wronskianetc.,
3. Enables the students to develop the strong background on modeling, formulating, solving and interpreting physicalproblems.

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**	**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)**	**18hours**

The Non- homogenous equations of order two-homogenous and Non - homogenous equations of order n - Initial value problems for n^{th}order equations- Annihilator method to solve non-Homogenous equation.

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

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 Legendreequations.

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

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

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

Equations with variable separated - Exact equations - The method of successive approximation - The Lipschitz Condition - Convergence of the successive approximation - Non-local existence of solutions - Approximations and uniqueness of solutions.

	Total Lecture hours	**90hours**

Text Book(s)

1 Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice-Hall of India Private Limited, New Delhi2008.

UNITI: Chapter2 : Sections 2.1 –2.5.
UNITII: Chapter2 : Sections 2.6 – 2.8,2.10,2.11.
UNITIII: Chapter3 : Sections 3.1 –3.8
UNITIV: Chapter4 : Sections 4.1 – 4.4, 4.6 –4.8
UNITV: 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 2012.
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.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/104/111104031/#
2	https://nptel.ac.in/courses/122/107/122107037/

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		**Core Paper IV:**COMPUTER ORIENTED NUMERICAL METHODS	**L**	**T**	**P**	**C**
Semester-I			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. To make the students understand solving Algebraic and Transcendentalequations.
2. To know about how and when to use various interpolation function finding thevarious numerical differentiation and integration formulae and using them to solveproblems.
3. To understand the methods of finding solution to the differential equations of variousorders.

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 Integration**	**18hours**

Solution of Nonlinear Equations: Newton's method – Convergence of Newton's method – Bairstow"s Method for quadratic factors.

Numerical Differentiation and Integration: Derivatives from Differences tables – Higher order derivatives – Divided difference, Central-Difference formulas– Composite formula of Trapezoidal rule – Romberg integration – Simpson'srules.

Unit:2	**Solution of System of Equations**	**18hours**

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 – Relaxation method – Systems of Nonlinear equations.

Unit:3	**Solution of Ordinary Differential Equations**	**18hours**

Taylor series method – Euler and Modified Euler methods – Runge-kutta methods – Multistep methods – Milne's method – Adams Moulton method.

Unit:4	**Boundary Value Problems and Characteristic Value Problems**	**18hours**

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.

Unit:5	**Numerical Solution of Partial Differential Equations**	**18hours**

Representation as a difference equation – 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 – solving the wave equation by Finite Differences.

	Total Lecture hours	**90hours**
Text Book(s)		
1	Curtis F. Gerald, Patrick O. Wheatley, Applied Numerical Analysis, Fifth 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.	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://nptel.ac.in/courses/111/107/111107105/	
2	https://freevideolectures.com/course/3504/numerical-methods-of-ordinary-and-partial/1	
3	https://www.classcentral.com/course/swayam-numerical-methods-for-engineers-14213	

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 -I:GRAPH THEORY**	**L**	**T**	**P**	**C**
Semester-I			**6**	**0**	**0**	**4**
Course Objectives:						

The main objectives of this course are to:

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

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	K3

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

Unit:1	**Graphs, Subgraphs and Trees**	**18 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 – Cayley's formula.

Unit:2	**Connectivity, Euler tours and Hamilton Cycles**	**18 hours**

Connectivity: Connectivity – Blocks.
Euler tours and Hamilton Cycles: Euler tours - Hamilton Cycles.

Unit:3	**Matchings and Edge Colourings**	**18 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**	**18 hours**

Independent sets, Cliques: Independent sets – Ramsey's theorem.
Vertex Colourings: Chromatic Number – Brook's Theorem – Hajo's Conjecture – Chromatic Polynomials – Girth and Chromatic number.

Unit:5	**Planar Graphs and Directed Graphs**	**18 hours**

Planar Graphs: Plane and planar Graphs – Dual Graphs – Euler's formula – Brides – Kuratowski's theorem (Proof omitted) – The Five Colour Theorem and the Four Colour Conjecture.
Directed Graphs: Directed Graphs.
Simple problems in the exercise of all units can also be included.

Total Lecture hours **90 hours**

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 – 2.4 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 – 8.5 Unit-V: Sections: 9.1 – 9.6,10.1
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.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/106/111106050/
2	https://nptel.ac.in/courses/106/108/106108054/

Mapping with Programme Outcomes										
COs POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**
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

Course code		Elective -I:NEURAL NETWORKS	L	T	P	C
Semester-I			6	0	0	4

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 andapplications.
2. Acquire in-depth knowledge in Non-lineardynamics
3. Apply neural network to classification and generalizationproblems.

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,	K6
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	18hours

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

Unit:2	Perceptron Architectures	18hours

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

Unit:3	Supervised Hebbian Learning	18hours

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

Unit:4	Back Propagation	18hours

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

Unit:5	Performance Surfaces and Performance Optimizations	18 hours

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

Total Lecture hours **90 hours**

Text Book(s) Martin T. Hagan, Howard B. Demuth and Mark Beale, Neural Network Design, Vikas Publishing House, New Delhi,2002.	
Reference Books	
1	James A. Freeman, David M. Skapura, Neural Networks Algorithms, Applications and Programming Techniques, Pearson Education, 2003.
2	Robert J. Schalkoff, Artificial Neural Network, McGraw-Hill International Edition, 1997.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/117/105/117105084/
2	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		Core Paper V:LINEAR 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 advancedstudies.
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 anddeterminants.

Expected Course Outcomes:

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

1	Understand the basic concepts of Linear transformations, characteristic roots and matrices of linear transformation and its applications.	K3
2	Explain about the algebra of polynomials, polynomial ideals and prime factorization of a polynomial.	K4
3	Understand the basic concepts of determinants and its additional properties.	K3
4	Recognize the concepts of Invariant subspaces and diagonalization process.	K2
5	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	18hours

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

Unit:2	Algebra of Polynomials	18hours

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

Unit:3	Determinants	18hours

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	18hours

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

Unit:5	The Rational and Jordan Forms	18hours
Cyclic subspaces – Cyclic decompositions theorem (Statement only) – Generalized Cayley – Hamilton theorem - Rational forms – Jordan forms.		

	Total Lecture hours	90hours

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.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.khanacademy.org/math/linear-algebra/vectors-and-spaces
2	https://nptel.ac.in/courses/111/106/111106051/

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

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

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

Course Objectives:

The main objectives of this course are to:

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

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 andsingularities.	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.	K6

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

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

Fundamental Theorems: LineIntegrals – 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.

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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**	**18hours**
Power Series Expansions: Weierstrass's Theorem – The Taylor Series – The Laurent Series - Partial fractions and Factorization: Partial Fractions – Infinite Products. .		
Unit:5	**Canonical Products**	**18hours**
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.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/103/111103070/
2	https://nptel.ac.in/courses/111/106/111106084/
3	https://youtu.be/sJcpfmF5oHo

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 VII:PARTIAL DIFFERENTIAL EQUATIONS**	**L**	**T**	**P**	**C**
Semester-II			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. Introduce different methods to solve partial differentialequation.
2. Acquire knowledge in classification of partial differential equations and the methods tosolve.
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 solve.	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**	**18hours**

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**	**18hours**

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**	**18hours**

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**	**18hours**

Elementary Solutions of the Diffusion Equation – Separation of variables – The use of Integral Transforms – The use of Green's functions.

	Total Lecture hours	**90hours**

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. Sankara Rao, 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
2	When do PDE NOT have solutions? https://www.youtube.com/watch?v=BmTFbUAOeec&list=PLGCj8f6sgswntUil8yzohR_qazOfYZCg_&index=49

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		**Core Paper VIII:OPTIMIZATION TECHNIQUES**	**L**	**T**	**P**	**C**
Semester-II			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. To make the students understand solving LPP using variousmethods.
2. To understand the application of queuing theory in real life situation and methods of solving relatedproblems.
3. To understand the concept of Kuhn tuckermethod.

Expected Course Outcomes:

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

1	Explain various techniques to solve real life problems expressed in terms of LPP.	K2
2	Solving LPP through Dynamic Programming	K3
3	Apply the fundamental concept of Inventory control.	K3

4	Understanding the queuing theory	K2
5	Solving NLPP using Kuhn–Tucker Method	K3

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

Unit:1	**Integer Programming**	**18hours**

Introduction – Integer Programming Formulations – Gomory's construction–Fractional cut method(all integer)–The Cutting – Plane Algorithm – Branch–and–Bound Technique – Zero– One Implicit Enumeration Algorithm.

Unit:2	**Dynamic Programming**	**18 hours**

Introduction – Application of Dynamic Programming: Capital Budgeting Problem – Reliability Improvement Problem – Stage–coach Problem – Cargo Leading Problem – Minimizing Total Tardiness in Single Machine Scheduling Problem – Optimal Subdividing Problem – Solution of Linear Programming Problem through Dynamic Programming.

Unit:3	**Inventory**	**18hours**

Introduction–Inventory Decisions–Cost Associated– with Inventories – Factors Affecting inventory – Economic Order Quantity–Deterministic Inventory Problems with No Shortages– Deterministic inventory Models with shortages–EOQ with Price Breaks–Multi Item Deterministic problems– Inventory Problems with Uncertain Demand.

Unit:4	**Queuing Theory**	**18hours**

Introduction – Queuing System–Elements of Queuing System – Operating Characteristics of Queuing System – Classification of Queuing Models– Model–I (M/M/1):(∞/FIFO), Model–II (M/M/1) : (N/FIFO), Model–III (M/M/C):(∞/FIFO), Model–IV (M/M/C):(N/FIFO). Problems in above four models.

Unit:5	**Nonlinear Programming**	**18 hours**

Introduction – Lagrangian Method –Jacobi Method– Kuhn–Tucker Method – Quadratic Programming – Separable Programming – Chance–Constrained Programming or Stochastic Programming.

	90hours

Text Book(s)	
1	Hamdy A. Taha, Operations Research, Sixth edition, Prentice–Hall of India private Limited, NewDelhi,1997.
Reference Books	
1	KantiSwarup, P. K. Gupta, Man Mohan, Operations Research, Sultan Chand & Sons, Educational Publishers, New Delhi.
2	Prem Kumar Gupta, D. S. Hira Operations Research, Seventh Edition, S. Chand & Company Pvt. Ltd, 2014.
3	F. S. Hillier and J. Lieberman, Introduction to Operation Research, Seventh Edition, Tata– McGraw-Hill Publishing Company, New Delhi, 2001.
4	R. Panneerselvam, Operations Research, Second Edition, PHI Learning Private Limited, Delhi, 2015.
5	I. Griva, S. G. Nash and A. Sofer, Linear and Nonlinear Optimization, SIAM Publication, 2018.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.youtube.com/watch?v=WmeUT0jQdwc
2	https://www.youtube.com/watch?v=FTEMe5oUrds&list=PLLy_2iUCG87Bq8RGMTdeFZ iB-87V4i9p1&index=28
3	https://www.youtube.com/watch?v=2aPlzhsEsIw
4	https://www.youtube.com/watch?v=PavZX3hAL6I

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

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

Course code		**Elective-II FUZZY LOGIC AND FUZZY SETS**	**L**	T	**P**	**C**
Course code		**Elective-II FUZZY LOGIC AND FUZZY SETS**	**L**	T	**P**	**C**
Semester-II			**6**	**0**	**0**	**4**

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**	**18hours**

Introduction-Crisp sets: An over view-The Notion of Fuzzy Sets-basic concepts of Fuzzy Sets – Classical Logic: complement-Fuzzy Union-Fuzzy intersection – Combination of operations – General aggregation of operations.

Unit:2	**Fuzzy Relations**	**18 hours**

Crisp and Fuzzy relations – Binary relations – Binary relations on a single set – Equivalence and similarity relations – Compatibility on Tolerance Relations-Orderings – Morphism – Fuzzy relations Equations.

Unit:3	**Fuzzy Measures**	**18 hours**

General discussion – Belief and plausibility Measures –Probability measures – Possibility and Necessity measures.		
Unit:4	**Fuzzy Measures, Uncertainty**	**18hours**
Relationship among classes of fuzzy measures - Types of Uncertainty – Measures of Fuzziness-Classical Measures of Uncertainty.		
Unit:5	**Uncertainty and Information**	**18hours**
Measures of Dissonance-Measures of Confusion – Measures of Non-Specificity – Uncertainty and Information – Information and Complexity – Principles of Uncertainty and information.		

	Total Lecture hours	**90 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 – 1.5, 2.2 - 2.6 Unit-II: 3.1 – 3.8 Unit-III: 4.1 – 4.4 Unit-IV: 4.5, 5.1 – 5.3 Unit-V: 5.4 – 5.9.	
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 MAGNETOHYDRODYNAMICS**	**L**	**T**	**P**	**C**
Semester-II			**6**	**0**	**0**	**4**

Course Objectives:

The main objectives of this course are to:

1. Understand the concepts of electromagnetism, electrostatic energy and magnetostaticenergy.
2. Gain knowledge about boundary conditions of electric and magneticfields.
3. Develop flexibility and creativity of the students in applying mathematical ideasand techniques to unfamiliar problems arising in everydaylife.

Expected Course Outcomes:

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

1	Understand the basic concepts of Electromagnetism, Fundamental Laws and fluid motion in magnetic field.	K2
2	Solve and analyze the Naiver-Stokes equations and velocity Magneto fluid dynamic equations with examples.	K3
3	Understand the MHD approximation and gain ability to analyze Magnetic Reynolds number.	K4
4	Gain knowledge about the Magneto hydrostatics and Alfven waves in incompressible MHD.	K5
5	Understand and develop the Hartmann Flow in the presence of magnetic field.	K6

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

Unit:1	**Title of the Unit (Capitalize each Word)**	**18hours**

Electromagnetism – Fundamental Laws – Electrostatic Energy – Electrodynamics Ampere's Law – Lorentz force on a moving charge – Magnetostatic Energy – Faraday's Law ofInduction – Poynting stresses.

Unit:2	**Title of the Unit (Capitalize each Word)**	**18 hours**
Electromagnetic Equations with respect to moving axes – boundary conditions of electric and magnetic fields. Kinematics of fluid motion – equation of continuity – Stress tensor – Navier-stokes equations – boundary condition – Velocity Magneto fluid dynamic equations.		
Unit:3	**Title of the Unit (Capitalize each Word)**	**18hours**
MHD approximation – equation of Magnetic diffusion in a moving conducting medium – Magnetic Reynolds number.		
Unit:4	**Title of the Unit (Capitalize each Word)**	**18hours**
Alfven's theorem Law of isorotation - Magneto hydrostatics – Force-free field – Alfven waves in incompressibleMHD.		
Unit:5	**Title of the Unit (Capitalize each Word)**	**18 hours**
Incompressible viscous flows in the presence of magnetic field – Hartmann Flow – unsteady Hartmann flow – Magneto fluid dynamic pipe flow.		

	Total Lecture hours	**90 hours**
Text Book(s)		
1	Crammer K.R. and Pai S.I, Magneto Fluid Dynamics for Engineers and Applied Physicists, McGraw Hill, 1973.	
2	Ferraro, VCA and Plumpton, Introduction to Magneto Fluid Dynamics, Oxford, 1966.	
Reference Books		
1	P. A. Davidson, An Introduction to Magnetohydrodynamics, Cambridge University press, 2001.	
2	R. V. Polovin, V. P. Demutskii, Fundamentals of Magnetohydrodynamics, Springer US, 1990.	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://www.youtube.com/watch?v=mE3uY_yKsCo	
2	https://www.youtube.com/watch?v=rFJ1UZSFZno	
3	https://www.youtube.com/watch?v=A9pUXEI128U	

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

CO4	**M**	**M**	**S**	**S**	**L**	**S**	**S**	**M**	**S**	**M**
CO5	**S**	**M**	**M**	**S**	**M**	**M**	**M**	**S**	**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. Tointroduce the concepts of point-set topology with emphasis on continuousfunctions, homeomorphism ,connectedness, compactness, countability and separationaxioms.

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	K1
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	K3
5	Understand the properties of the compact spaces and analyse the different types of compactness.	K4

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

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

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**	**18hours**
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**	**18hours**
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**	**18hours**
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**	**18hours**
The UrysohnMetrization Theorem - Tietze Extension Theorem - The Tychonoff theorem – Stone Cechcompactifications.		

	Total Lecture hours	**90hours**
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 10**
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

infinite flat plate – Blasius equation and its solution in series.

Course code		Core Paper X: FLUID DYNAMICS	**L**	**T**	**P**	**C**
Semester-III			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. able to know the fundamental concepts of fluids and itsproperties.
2. develop the problems solving skill in fluiddynamics.
3. know the real-life applications of fluiddynamics.

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**	**18 hours**

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

Unit:2	**Equations of Motion (Contd)**	**18hours**

Euler's momentum Theorem – Conservative forces – Bernoulli's theorem in steady motion – energy equation for inviscid fluid – circulation – Kelvin's theorem – vortex motion – Helmholtz equation.

Unit:3	**Two-Dimensional Motion**	**18 hours**

Two Dimensional Motion – Two Dimensional Functions – Complex Potential – basic singularities – source – sink – Vortex – doublet – Circle theorem. Flow past a circular cylinder with circulation – Blasius Theorem – Lift force. (Magnus effect)

Unit:4	**Dynamics of Real Fluids**	**18 hours**

Viscous flows – Navier-Stokes equations – Vorticity and circulation in a viscous fluid – Steady flow through an arbitrary cylinder under pressure – Steady Couette flow between cylinders in relative motion – Steady flow between parallel planes.

Unit:5	**The Laminar Boundary Layer in Incompressible Flow**	**18 hours**

Boundary Layer concept – Boundary Layer equations – Displacement thickness, Momentum thickness – Kinetic energy thickness – integral equation of boundary layer – flow parallel to semi

	Total Lecture hours	**90 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., 3.10-3.41 (omit3.32) Chapter III : Sections 3.42 – 3.53 (omit3.44)
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 – 3.7.5 (omit 3.3.4, 3.4,3.5.2,3.6) ChapterV : Sections 5.2.1– 5.3.3 ChapterVI : Sections 6.1 – 6.3.1 (omit 6.2.2.,6.2.5)

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 10**
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		**Core Paper XI:DIFFERENTIAL GEOMETRY**	**L**	**T**	**P**	**C**
Semester-III			**6**	**0**	**0**	**4**
Course Objectives						
The main objectives of this course are to: 1. Gain knowledge about curves and itscharacterizations. 2. Get sufficient knowledge on Elementary Theory ofsurfaces. 3. Make the students to familiarize with space curves and curves onsurfaces.						
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 surface.	K3

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

Unit:1	Representation and Theory of SpaceCurves:	**21 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:**	**18hours**

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	**18hours**

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 normalproperty.

Unit:5	Existence Theorems:	**18hours**

Existence theorems proof- Geodesic parallels - Geodesic polar coordinates – Geodesic curvature - Gauss-bonnet theorem-Meusnieu‟s theorem-Gaussian curvature Euler‟s theorem- Duplin‟sindicarix-Surface of revolution conjugate system-Asymmetric lines-isometric lines

	Total Lecture hours	**90hours**

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

COs / POs	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 XII: PROGRAMMING IN PYTHON	L	T	P	C
Semester-III			4	0	0	4

Course Objectives:

The main objectives of this course are to:

1. To introduce the fundamentals of PythonProgramming.
2. To teach about the concept of Functions inPython.
3. To impart the knowledge of Lists, Tuples, Files andDirectories

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	12hours

Introduction to Python**:** 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:	12hours

Functions: 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. Strings**:** Compound Data Type - Len Function - String Slices - Strings are Immutable - String Traversal - Escape Characters - String Formatting Operator - String FormattingFunctions.

Unit:3	Lists	12hours

Lists: Values and Accessing Elements - Lists are Mutable - Deleting Elements from List- Built-in list Operators - Built-in List Methods. Tuples**:** Creating Tuples - Accessing values in Tuples - Tuples are Immutable - Tuple Assignment - Tuples as Return Values - Variable Length Argument Tuples - Basic Tuple Operations - Built-in Tuple Functions.

Unit:4	Dictionaries	12hours

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. Classes and Objects: Overview of OOP - Class Definition - Creating Objects - Objects as arguments - Objects as Return Values - Built-in class attribute - Inheritance - Method Overriding - Data Encapsulation - DataHiding.

Unit:5	**Files**	**12hours**

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. Directories: mkdir(), chdir(), getcwd(), rmdir(). Exceptions: Built-in exceptions - Handling exceptions - Exception with arguments - User defined exceptions.

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

	Total Lecture hours	**60hours**

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 NamdevKamthane,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

Course code		Core Practical-I: Programming in Python - Practical	L	T	P	C
Semester-III			0	0	2	2

Course Objectives:

The main objectives of this course are to:

1. To gain knowledge about the concepts of Pythonprogramming.
2. To solve algebraic and non-linear ordinary differential equations using Pythonprograms.
3. To enhance the students to develop the program writing skills for mathematicalproblems.

Expected Course Outcomes:

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

1	Understand the concept of Pythonprogramming	K2
2	Utilizing Python program for finding the Numerical solutions of Algebraic and Transcendental Equations.	K3
3	Analyzing the GCD, interpolation values and File management using Python programs	K4
4	implement basic operators and function concepts.	K5
5	Applying, compiling and debugging programs with the help of Python	K6

LIST OF PRACTICAL PROGRAMS

1. Program to determine the Greatest Common Divisor (GCD) of any twointegers.
2. Program to accept two complex numbers and find theirsum.
3. Program to generate randomnumbers.
4. Program to display the Pascal'striangle.
5. Program to find the number of instances of different digits in a givennumber.
6. Program to find the number of vowels and consonants in a textstring.
7. Program to find the numerical solution of algebraic and transcendental equations byusing
   (i) BisectionMethod.
   (ii) Newton RaphsonMethod.
8. Program to solve an ordinary differential equation by using Fourth order Runge-KuttaMethod.
9. Program to find the interpolation value using Lagrange'smethod.
10. Program to find the inverse of a matrix by Gauss Jordanmethod.
11. Program to solve the simultaneous equationsby
    (i) Gauss EliminationMethod

(ii) Gauss SeidelMethod

12. Program to demonstrate File Input and Outputoperations.

13. Program to demonstrate Classes and theirAttributes

Distribution of MarksinESE	CIA
Experiment : 50 Record : 10	CIAPracticalExam : 25 Attendance : 5 Observation Note Book : 10
Total : 60	Total : 40

To be awarded jointly by the internal and external examiners

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-III:MATHEMATICAL STATISTICS	L	T	P	C
Semester-III			6	0	0	4

Course Objectives:

The main objectives of this course are to:

1. Enables to learn different aspects ofstatistics.
2. Acquire knowledge about moments and properties of theoreticaldistributions.
3. Study unbiasedness and consistency of limitingdistributions.

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 distributions.	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	18hours

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

Unit:2	Probability and Distributions (continued) and Multivariate Distributions	18hours

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

Multivariate Distributions: Distributions of Two Random Variables - Transformations: Bivariate Random Variables - Conditional Distributions and Expectations - Independent RandomVariables.

Unit:3	Some Special Distributions	18hours

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

Unit:4	Some Special Distributions (continued), Unbiasedness, Consistency and Limiting Distributions	18hours

Some Special Distributions (continued): t and F-Distributions. **Unbiasedness, Consistency and Limiting Distributions:** Expectations of Functions - Convergence in Probability - Convergence in Distribution - Central Limit Theorem.

Unit:5	**Some Elementary Statistical Inferences**	**18hours**
Sampling and Statistics – More on Confidence Intervals - Introduction to Hypothesis Testing - Additional Comments About Statistical Tests - Chi-Square Tests – The Method of Monte Carlo.		
	Total Lecture hours	**90hours**

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 –1.7 Unit-II: 1.8 – 1.10, 2.1 – 2.3,2.5 Unit-III: 3.1 –3.4 Unit-IV: 3.6, 4.1 –4.4 Unit-V: 5.1, 5.4 –5.8
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. Ehsanes Saleh, 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 10**
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: NUMBER THEORY	L	T	P	C
Semester-III			6	0	0	4

Course Objectives:

The main objectives of this course are to:

1. To give Introduction to Elementary NumberTheory.
2. To show how certain number theorems can be applied withinCryptography.

Expected Course Outcomes:

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

1	Find quotients and remainders and greatest common divisors applying Euclidean Algorithm	K3
2	Understand the definitions of congruence, residue classes and least residues	K2
3	Analyze the concept of Prime Power Moduli and Quadratic Residues	K4
4	Determine multiplicative inverses, modulo n and use to solve linear congruence.	K3
5	Acquire knowledge on Linear Diaphantine equation	K4

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

Unit:1	Divisibility	18hours

Divisibility and Euclidean algorithm.

Unit:2	Congruences	18hours

Congruences, Euler's theorem, Wilson's Theorem. Solutions of congruences, Congruences of Degree 1. Chinese Remainder Theorem, The functions φ(n), Congruences of higher degree.

Unit:3	Congruences (contd), Quadratic Reciprocity	18hours

Prime power moduli, Prime modulus. Quadratic residues - Quadratic reciprocity.

Unit:4	Jacobi Symbol and Some Functions of Number Theory	18hours

The Jacobi symbol – Greatest integer function - Arithmetic functions – The Moebius Inversion formula.

Unit:5	Arithmetic Functions and Diophantine Equations	18hours

Multiplication of arithmetic functions, Linear Diophantine equations – The equation $x^2 + y^2 = z^2$ - The equation $x^4 + y^4 = z^2$.		
	Total Lecture hours	**90 hours**

Text Book(s)	
1	Ivan Niven and Herbert Zuckerman, An Introduction to the Theory of Numbers, John Wiley and Sons Inc., 1972. Unit-I: Chapter I: Sections: 1.1–1.3 Unit-II: ChapterII: Section: 2.1 –2.5 Unit-III: Chapter II: Section: 2.6 – 2.7, Chapter III: Section: 3.1–3.2 Unit-IV: Chapter III: Section: 3.3, Chapter IV: Section: 4.1–4.3 Unit-V: Chapter IV: Section: 4.4, Chapter V: Section: 5.1 –5.6
Reference Books	
1	T. M. Apostol, Introduction to Analytic Number Theory, Springer Verlag, 1976.
2	Kenneth H. Rosen, Elementary Number Theory and its Applications, Addison Wesley Publishing Company, 1968.
3	George E. Andrews, Number Theory, Hindustan Publishing, New Delhi, 1989.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https:// freevideolectures.com/course/3027/cryptography-and-network-security
2	https://www.youtube.com/watch?v=SCvtxjpVQms&t=3321s (NPTEL)
3	https://www.youtube.com/watch?v=Oyw5OmOd9B8&list=PLLtQL9wSL16iRzTi2aKPiHO1f1UjTTkJD (Mathpod)

Mapping with Programme Outcomes

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

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

Course code		Core Paper XIII:**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 Spaces**	**18hours**

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 spaces**	**18hours**

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)**	**18hours**

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**	**18hours**
Matrices – Determinants and the spectrum of bounded operator – The spectral theorem.		
Unit:5	**General Preliminaries on Banach Algebras**	**18hours**
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	**90hours**

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 code		Core Paper XIV: **MESURE THEORY**	L	T	P	C
Semester-IV			**6**	**0**	**0**	**5**

Course Objectives:

The main objectives of this course are to:

1. Understand the concepts of outer measures andintegrals
2. Provide the relationship between Riemann and Lebesgueintegral
3. Learner will be derive integration and derivates by using Radon-NikodymTheorem and Fubini‟sTheorem
4. Gain understanding of the abstract measure theory and definition and main properties of theintegral.
5. To constructLebesgue's measure on the real line and in n-dimensionalEuclidean space.
6. To explain the basic advanced directions of thetheory

Expected Course Outcomes:

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

1	Understanding the basic concepts of the definition of general Lebesque integral.	K2
2	Derives the concepts of Borel sets, measurable functions, differentiation of monotone functions	K1& K5
3	Demonstrate statement of main results in fundamental integral theorems, monotone convergence theorem, and its related proves and results.	K2& K5
4	Demonstrate the proof in integration in product spaces and signed measures.	K2
5	Apply the theory of this course to solve real problems in difficult situations.	K5& K6

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

Unit:1	**Lebesgue Measure**	**18 hours**

Lebesgue Measure introduction- Lebesgue Outer Measure – Measurable Sets Regularity Measurable Functions – every interval is measurable- Borel set- outer measure of intervalequalsit‟s length- regular measure- Borel and LebesgueMeasurability

Unit:2	Borel And Lebesgue Measure	18 hours

Borel And Lebesgue Measure introduction– Hausdorff measures on the Real Line – Hausdorff Dimension - Integration of non-negative Functions -Fatou‟s Lemma- Lebesgue‟s Monotone Convergence Theorem – General Integral – Lebesgue‟s Dominated Convergence Theorem - Integration of series – Riemann and Lebesgue Integral

Unit:3	R-S Integral	18 hours

R-S Integral introduction- Abstract Measures space – Measures and Outer Measures- Extension of a Measure – Uniqueness of Extension - Completion of a Measure – Measure Spaces – Integration with respect to a Measure – L^p Spaces – Convex Functions –Jensen‟s Inequality – Completeness.

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Unit:4	Signed Measure	18 hours

Signed Measure introduction - Signed Measure and the Hahn Decomposition - Definition of Positive Set, Negative Set, Null Set– the Jordan Decomposition –Definition of Mutually singular– Radon-Nikodym Theorem – Some Application of The Radon-Nikodym Theorem – Randon-Nikodym derivation –Lebesgue Decomposition Theorem

Unit:5	Measurability in a Product Space	18 hours

Measurability in a Product Space introduction – Definition of Measurable Rectangle and Elementary Sets- Fubini‟s Theorem– The Product Measure and Fubini‟s Theorem -Definition of Monotone Class- Fubini‟s Theorem – Theorem on Fubini‟s Theorem

	Total Lecture hours	90 hours

Text Book(s)

1 **G.De Barra,** “Measure Theory and Integration”, 1st edt, New age international (p) Limited, 2003

Unit – I: Chapter II: Sections 2.1 to 2.5
Unit – II: Chapter III: Sections 3.1 to 3.4
Unit – III: Chapter V: Sections 5.1 to 5.6
Unit – IV: Chapter VII: Sections 7.1 and 7.2,
Chapter VIII: Sections 8.1 and 8.2
Unit – V: Chapter X: Sections 10.1 and 10.2

Reference Books		
1		**I.K. Rana,** "An Introduction to Measure and Integration", Narosa Publishing House, NewDelhi,1999
2		**H.L.Royden**"Real Analysis", Prentice Hall of India 2001edition.
3		**P.R. Halmos,** "Measure Theory", D.VanNostrand Company, Inc. Princeton, N.J.,1950
4		**D.L. Cohn,** "Measure Theory", Birkhauser, Switzerland,1980
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1		https://nptel.ac.in/courses/111/107/111107103/
2		https://nptel.ac.in/courses/111/107/111107098/(Lec 51 to 55)
3		https://youtu.be/tfRZqIflEfQ

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

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

Course code		**Elective -IV:ELEMENTS OF STOCHASTIC PROCESSES**	**L**	**T**	**P**	**C**
Semester-IV			**6**	**0**	**0**	**4**

Course Objectives:
The main objectives of this course are to: 1. Acquire knowledge about the concept of Markov Chain and QueueingSystem. 2. Understand the methods of Birth and Death queues with Finite and InfiniteCapacity. 3. Develop the ability of Standard BrownianMotion.
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 Systems.	K1

2	Gain understanding on the Renewal Process, Cumulative Process and Semi-Markov Process.	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.	K4
5	Conclude the idea of Brownian Motion and First Passage Times.	K5

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

Unit:1	**Continuous-Time Markov Models**	**18hours**
Continuous Time Markov Chain, Examples, Transient Analysis, Occupancy Times, Limiting Behavior.		

Unit:2	**Generalized Markov Models**	**18 hours**
Renewal Process, Cumulative Process, Semi-Markov Process, Examples and Long term Analysis.		

Unit:3	**Queueing Models**	**18 hours**
Queueing Systems, Single-Station Queues, Birth and Death queues with Finite and Infinite Capacity.		

Unit:4	**Queueing Models (Contd)**	**18 hours**
M/G/1 and G/M/1 Queues and Network of Queues.		

Unit:5	**Brownian Motion**	**18hours**
Standard Brownian Motion, Brownian Motion and First Passage Times.		

	Total Lecture hours	**90 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**	**PO10**
CO1	**M**	**S**	**M**	**S**	**M**	**S**	**S**	**L**	**S**	**S**
CO2	**S**	**M**	**L**	**M**	**L**	**M**	**L**	**M**	**S**	**M**
CO3	**S**	**S**	**M**	**M**	**M**	**M**	**S**	**L**	**M**	**M**
CO4	**M**	**M**	**S**	**S**	**S**	**S**	**M**	**M**	**S**	**S**
CO5	**M**	**M**	**M**	**S**	**M**	**M**	**S**	**M**	**S**	**S**

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

Course code		**Elective-IV: CONTROL THEORY**	**L**	**T**	**P**	**C**
Semester-IV			**6**	**0**	**0**	**4**

Course Objectives:

The main objectives of this course are to:

1. Understand the concepts of Observability, Controllability andStability.
2. Gain knowledge about linear time varyingsystems.
3. Develop the ability of solving linear feedbackcontrol.

Expected Course Outcomes:

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

1	Explain observability and estimate the observability of constant coefficient system, linear, nonlinear system, and discuss reconstruction kernel.	K2
2	Apply controllability criteria to constant coefficient system, linear, nonlinear system, and explain steering function.	K3
3	Analyze the stability of linear system, linear time varying system, perturbed linear system and nonlinear system.	K4
4	Evaluate stabilizabilization via linear feedback control, Bass method.	K5
5	Analyze controllable subspace, and stabilization with restricted feedback.	K4

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

Unit:1	**Observability**	**18 hours**

Linear Systems – ObservabilityGrammian – Constant coefficient systems – Reconstruction kernel – Nonlinear Systems.

Unit:2	**Controllability**	**18hours**
Linear systems – Controllability Grammian – Adjoint systems – Constant coefficient systems – steering function – Nonlinear systems.		
Unit:3	**Stability**	**18hours**
Stability – Uniform Stability – Asymptotic Stability of Linear Systems.		
Unit:4	**Perturbed Linear Systems**	**18hours**
Linear time varying systems – Perturbed linear systems – Nonlinear systems.		
Unit:5	**Stabilizability**	**18hours**
Stabilization via linear feedback control – Bass method – Controllable subspace – Stabilization with restricted feedback.		
	Total Lecture hours	**90hours**

Text Book(s)	
1	K. Balachandran and J. P. Dauer, Elements of Control Theory, Narosa, New Delhi, 1999.
Reference Books	
1	R. Conti, Linear Differential Equations and Control, Academic Press, London, 1976.
2	R. F. Curtain and A. J. Pritchard, Functional Analysis and Modern Applied Mathematics, Academic Press, New York, 1977.
3	J. Klamka, Controllability of Dynamical Systems, Kluwer Academic Publisher, Dordrecht, 1991.
4	D. L. Russell, Mathematics of Finite Dimensional Control Systems, Marcel Dekker, New York, 1979.
5	E. B. Lee and L. Markus, Foundations of optimal Control Theory, John Wiley, New York, 1967.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.youtube.com/watch?v=39Ggoj2fQ2c
2	https://nptel.ac.in/courses/115/108/115108104/
3	https://nptel.ac.in/courses/107/106/107106081/

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

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

Course code		**Core Paper XV: Project**	**L**	**T**	**P**	**C**
Semester-IV			**12**	**0**	**0**	**4**

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	K4
2	Analyzing results with the existing results.	K5
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