

**ETHIRAJ COLLEGE FOR WOMEN  
(AUTONOMOUS)  
CHENNAI-600 008  
COLLEGE WITH POTENTIAL FOR EXCELLENCE  
DEPARTMENT OF MATHEMATICS**

**M.PHIL  
SYLLABUS**



**Choice Based Credit System  
Outcome Based Education**

**(Offered from the academic year 2021-22)**

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## Department of Mathematics

### Revised M.Phil Syllabus with effect from June 2021 (CBCS-OBE Pattern)

#### Preamble

As per the guidelines given by the University Grants Commission and the Tamil Nadu State Council for Higher Education, the M. Phil degree program is designed in such a way to have a foundation in discrete and continuous Mathematics; a Mathematical attitude towards problem formulation and solving; an analytical skill and desire for correctness; an appreciation towards approaching of Mathematical techniques; the programming skill at higher level computer language and research aptitude to Mathematics.

#### Objectives of the course :

- To provide students a firm grip on all the facets of pure and applied mathematics and inculcate the student, an ardor for mathematical knowledge.
- To propel the student towards higher academic ambitions in Advanced Mathematics.
- To develop in the student logical, heuristic, systematic and critical ways of thinking to assist in problem solving in their chosen career.
- To provide the student some inputs in teaching methodology and psychology of teaching.

#### REGULATIONS

##### 1. ELIGIBILITY FOR ADMISSION:

All candidates should have passed two year PG degree course after three year degree course and higher secondary of 12 years duration or pre –university and 11 year SSLC plus one year or 10+2 pattern.. Candidates who have secured a minimum of 55% in M.Sc., Mathematics are alone eligible to apply. SC/ST candidates should have a minimum of 50% in M.Sc., Mathematics to apply. Candidates who have passed the PG degree examination with less than 17 years of total duration of the course are not eligible for admission to M. Phil degree course.

**2. DURATION OF THE PROGRAMME: 1 Year (Full time)**

One year M. Phil course is divided into two semesters. In the first semester two core papers are covered. In the second semester, one specialization paper (Internal) is covered along with the submission of dissertation.

**3. COURSE OF STUDY**

The main subject of study for M. Phil Degree shall consist of the following:

Part - I : Algebra and Analysis

Part - II : Topology and Geometry

**4. PASSING MINIMUM**

A candidate shall be declared to have passed in each paper / dissertation of the main subject of study wherever prescribed, if she secured NOT LESS THAN 50% of the marks prescribed for the examination.

**5. CLASSIFICATION OF SUCCESSFUL CANDIDATES:****Part I & II**

Successful candidates passing the examination and securing the marks (i) 60 percent and above and (ii) 50 percent and above but below 60 percent in the aggregate shall be declared to have passed the examination in the FIRST and SECOND class respectively. All other candidates shall be declared to have failed in the M Phil examination.

## **PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)**

On obtaining a research degree the scholar will be able to:

**PEO 1** - Demonstrate advanced domain knowledge competencies and display high order discerning and synthesizing capabilities to address local, regional and national concerns through innovative well researched solutions.

**PEO2** - Continue to serve the community of professionals and experts as both independent and team player with a strong grounding in ethics, inclusivity, gender parity and environmental sustainability.

## PROGRAMME OUTCOMES (POs)

On completion of the Programme, the learner will be able :

- PO1** - To acquire advanced conceptual knowledge and comprehensive understanding of the fundamental principles in respective discipline.
- PO2** - To apply knowledge and critically evaluate the concepts and scientific developments to take up any challenge.
- PO3** - To visualize and work on laboratory multidisciplinary tasks related to current research in the fields of Mathematical, Physical and Life sciences
- PO4** - To acquire research based knowledge and design methods to conduct investigations of complex problems in research/ Industrial field and achieve employability / self employment.
- PO5** - To communicate effectively ideas verbally in English, leading to Entrepreneurship ventures such as consultancy and training.
- PO6** - Employ innovative and environment friendly methods, novel ideas to solve complex and challenging societal and environmental issues.

## **PROGRAMME SPECIFIC OUTCOME (PSOs)**

On completion of the M.Phil Mathematics the student will be able

**PSO 1:** To develop research level thinking in the field of pure and applied mathematics.

**PSO 2:** To develop abstract mathematical thinking.

**PSO 3:** To assimilate mathematics independently and solve advanced mathematical problems.

**PSO 4:** To write research articles in mathematics and to publish it in reputed journals.

**PSO 5:** To develop and enhance teaching skills in mathematics.

**PROGRAMME PROFILE –M.Phil MATHEMATICS**

SEM	COURSE CODE	PAPER	TITLE OF THE PAPER	CRE DITS	HOURS/ WK	TOTAL HOURS	CA	SE	TOTAL
I	11M21/ALA	Paper I	Algebra & Analysis	5	6	90	40	60	100
I	11M21/TGY	Paper II	Topology And Geometry	5	6	90	40	60	100
II	11M21/SP/AAL 11M21/SP/FTA 11M21/SP/GRT 11M21/SP/CAN	Paper III	Specialization Paper	5	6	90	40	60	100
II	11M/DIS		Dissertation	21	12		100	100	200
			Total Credits	36					



**EVALUATION PATTERN FOR CONTINUOUS ASSESSMENT-M.Phil**

(a) Assignment/ Seminar (Report to be prepared and presented)	10 marks
(b) Participatory Learning/ Problem Solving/ Group Discussion	10 marks
(c) Test 1 ( 2 Hours – 50 marks )	10 marks
(d) Test 2 ( 2 Hours – 50 marks )	10 marks
<b>TOTAL</b>	<b>40 Marks</b>

**RUBRICS FOR CONTINUOUS ASSESSMENT**

<b>Assignment</b>	Content/originality/Presentation/Schematic Representation and Diagram/Bibliography
<b>Seminar</b>	Organisation/Subject Knowledge/Visual Aids/Confidence level/presentation-Communication and Language
<b>Participation Learning</b>	Answering Questions/Clearing Doubts/Participating in Group Discussions/Regular Attendance/ communication and language

**END SEMESTER EVALUATION PATTERN- M.Phil**

<b>Knowledge level</b>	<b>Components</b>	<b>Nature of the Question</b>	<b>Maximum Marks</b>	<b>Special Instructions if any</b>
K <sub>5</sub> , K <sub>6</sub>	Part A	Understanding Description/ Problems	5 x 20 =100 Marks	At least 2 questions to be answered out of 4 questions from Part A.
K <sub>5</sub> , K <sub>6</sub>	Part B	Understanding Description/ Problems		At least 2 questions to be answered out of 4 questions from part B.

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**SEMESTER I COURSE PROFILE-PROGRAMME OF STUDY**

<b>COURSE CODE</b>	<b>PAPER</b>	<b>TITLE OF THE PAPER</b>	<b>CREDITS</b>	<b>HRS/ WK</b>	<b>TOTAL HOURS</b>	<b>L-T-P</b>	<b>CA</b>	<b>SA</b>	<b>TOTAL</b>
<b>11M21/ALA</b>	<b>Paper I</b>	<b>Algebra &amp; Analysis</b>	<b>5</b>	<b>6</b>	<b>90</b>	<b>3 - 3 - 0</b>	<b>40</b>	<b>60</b>	<b>100</b>
<b>11M21/TGY</b>	<b>Paper II</b>	<b>Topology And Geometry</b>	<b>5</b>	<b>6</b>	<b>90</b>	<b>3 - 3 - 0</b>	<b>40</b>	<b>60</b>	<b>100</b>
		<b>TOTAL CREDITS</b>	<b>10</b>						

**SEMESTER – I**  
**ALGEBRA AND ANALYSIS**

**Paper: I****Course Code : 11M21/ALA****Teaching hours: 90 hours****Credits : 5 L T P : 3 3 0****COURSE OBJECTIVES:**

To enable the students to

- achieve an advanced mastery of representations of associative algebras.
- realise the importance of modules as central objects in algebra and to study some applications.
- gain knowledge of the theory of semi simple algebras
- state the axioms of  $L_p$  spaces.
- apply appropriate techniques of integration to product spaces.

**COURSE OUTLINE:****UNIT – I :** The Associative Algebra**Chapter 1 (Section 1.1 – 1.7 (Omit section 1.5)) (20 hours)****UNIT- II :** Modules**Chapter 2 (Section 2.1 – 2.7) (18 hours)****UNIT- III :** The Structure of Semi – Simple Algebras**Chapter 3 (Section 3.1 – 3.6) (18 hours)****UNIT- IV :**  $L^p$  Spaces – Elementary Hilbert Space Theory**Chapter 3,4 (17 hours)****UNIT- V :** Integration on Product Spaces**Chapter 8 (17 hours)****BOOKS RECOMMENDED:**

1. Richard S. Pierce, Associative Algebras Springer Publications (2012) First Edition  
(For Unit I, II, III)
2. Walter Rudin, Real And Complex Analysis (2011), Springer Publications, Third Edition  
(For Units IV and V)

**REFERENCE BOOKS:**

1. Algebra Michael Artin (1994), Prentice Hall of India.
2. Algebra ,(Third Edition )Serge Lang ,1999.
3. An Introduction to Measure and Integration Theory .K.Rana ,Second Edition , 2009,NarosaPublications.

**PERIODICALS:**

The Mathematics Intelligencer  
 Mathematics Newsletters  
 Journal in Algebra and Number Theory  
 Journal of Algebraic combinatorics

**WEBSITES & e-LEARNING SOURCES:**

1. <https://www.nptel.ac.in/courses/111/101/111102009/>
2. <https://www.nptel.ac.in/content/storage2/courses/111101005/>
3. <https://sites.math.northwestern.edu/~len/d70/chap5.pdf>
4. <https://www.math.ksu.edu/~nagy/real-an/4-03-lp-spaces.pdf>
5. [https://link.springer.com/chapter/10.1007/978-3-642-88044-5\\_6](https://link.springer.com/chapter/10.1007/978-3-642-88044-5_6)

**COURSE OUTCOMES:**

Upon successful completion of Algebra and Analysis, Students will be able to:

CO NUMBER.	CO STATEMENT
CO 1	Integrate knowledge at the forefront of associative algebra which forms the basics of higher mathematics.
CO 2	Investigate the properties of modules and appreciate its important results.
CO 3	Learn about semi simple algebras and be familiar with examples.
CO 4	Define the $L^p$ spaces and determine whether functions are in $L^p$
CO 5	Evaluate problems in product spaces using the powerful concept of integration.

**MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME**

CO / PSO	PSO 1	PSO 2	PSO3	PS04	PSO5
<b>CO 1</b>	3	3	3	3	3
<b>CO 2</b>	3	2	2	3	3
<b>CO 3</b>	3	3	3	3	3
<b>CO 4</b>	3	2	2	3	2
<b>CO 5</b>	3	2	2	3	2
<b>Average</b>	<b>3</b>	<b>2.4</b>	<b>2.4</b>	<b>3</b>	<b>2.6</b>

**KEY: STRONGLY CORRELATED-3 MODERATELY CORRELATED-2 WEAKLY CORRELATED-1 NO CORRELATION-0**

**TEACHING METHODOLOGY:**

Lecture (chalk and talk),

Problem Solving,

Discussion and Interactive session,

Assignment,

Seminar.

**QUESTION PAPER TEMPLATE**

Knowledge level	Components	Nature of the Question	Maximum Marks	Special Instructions if any
K <sub>5</sub> , K <sub>6</sub>	Part A	Understanding Description/Problems	5 x 20 = 100 Marks	Atleast 2 questions to be answered out of 4 questions covering all the Algebra units
K <sub>5</sub> , K <sub>6</sub>	Part B	Understanding Description/Problems		Atleast 2 questions to be answered out of 4 questions covering all the Analysis units

**TOPOLOGY AND GEOMETRY**

**Paper : II**  
**TOTAL HOURS: 90**

**COURSE CODE: 11M21/TGY**  
**Credits: 5      L-T-P : 3 3 0**

**COURSE OBJECTIVES:**

1. To understand various higher level topics in Topology, Geometry, Methods And Psychology of Teaching Mathematics
2. To equip the students in pursuing research in Mathematics
3. To prepare the student for lectureship in Mathematics.
4. To understand and generalize the classical theorems in Calculus.
5. To know the basic notions of homotopy theory.

**COURSE OUTLINE:**

**UNIT I : The Fundamental Group**

**Chapter 9 (Section 51 – 52) (20 hours)**

**UNIT II : Covering Spaces – The Fundamental Group of the Circle**

**Chapter 9 (Section 53 – 54) (19 hours)**

**UNIT III : The Borsuk – Ulam Theorem - Deformation Retracts and Homotopy Type – The Fundamental Group of  $S^n$**

**Chapter 9 (Sections 57 – 59) (18 hours)**

**UNIT IV: Differential Forms in  $R^n$  - Line Integrals**

**Chapter 1 & Chapter 2 (16 hours)**

**UNIT V: Differentiable Manifolds- Integration on Manifold's, Stokes's theorem and Poincare's Lemma.**

**Chapter 3 & Chapter 4 (17 hours)**

**BOOKS RECOMMENDED:**

James R. Munkres, TOPOLOGY, Second Edition, Prentice Hall of India Private Ltd, New Delhi, 2012.

**REFERENCE BOOKS:**

1. W. S. Massy, A basic course in Algebraic Topology, Springer Verlag, 1991, Indian Reprint, new Delhi, 2001.
2. R. Anant Shastri, Basic Algebraic Topology, Chapman and Hall, 2013.
3. H. Edwin Spanier, Algebraic Topology, Springer, 2008.
4. J. Peter May, A concise Course in Algebraic Topology, The University of Chicago press, London, 1999.

**PERIODICALS:**

1. Mathematics Newsletter
2. Discrete Mathematical Sciences and Cryptography.
3. Journal of Topology and its Applications
4. Journal of Differential Geometry

**WEBSITES & E-LEARNING SOURCES:**

1. <https://www.nptel.ac.in/courses/111/101/111101002/>
2. <https://ocw.mit.edu/courses/mathematics/18-965-geometry-of-manifolds-fall-2004/lecture-notes/lecture1.pdf>

**COURSE OUTCOME:**

Upon successful completion of Topology and Geometry, Students will be able to:

<b>CO NUMBER</b>	<b>CO STATEMENT</b>
<b>CO 1</b>	Construct the fundamental group of a topological space.
<b>CO 2</b>	Understands the connection between covering spaces and fundamental group.
<b>CO 3</b>	Work with cell complexes and the basic notions of homotopy theory.
<b>CO 4</b>	Solve the calculations with differential forms and characterize the exterior Derivative.
<b>CO 5</b>	Know Stroke's theorem and understand how this generalizes classical theorems in Calculus.



**MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME**

CO / PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	2	3	2	2	3
CO 2	3	3	3	2	3
CO 3	3	3	3	2	3
CO 4	3	3	3	2	3
CO 5	3	3	3	2	3
<b>AVERAGE</b>	2.8	3	2.8	2	3

**KEY: STRONGLY CORRELATED-3 MODERATELY CORRELATED-2 WEAKLY CORRELATED-1 NO CORRELATION-0**

**TEACHING METHODOLOGY:**

Problem Solving-Group Discussion

Quiz-Seminar

Peer Learning

**QUESTION PAPER TEMPLATE**

Knowledge level	Components	Nature of the Question	Maximum Marks	Special Instructions if any
K <sub>5</sub> , K <sub>6</sub>	Part A	Understanding Description/ Problems	5 x 20 =100 Marks	At least 2 questions to be answered out of 4 questions covering all the Topology units.
K <sub>5</sub> , K <sub>6</sub>	Part B	Understanding Description/ Problems		At least 2 questions to be answered out of 4 questions covering all the Geometry units.

**SEMESTER II COURSE PROFILE-PROGRAMME OF STUDY**

<b>COURSE CODE</b>	<b>TITLE OF THE PAPER</b>	<b>CREDITS</b>	<b>HOURS/WK</b>	<b>TOTAL HOURS</b>	<b>L-T-P</b>	<b>CA</b>	<b>SA</b>	<b>TOTAL</b>
11M21/SP/AAL 11M21/SP/FTA 11M21/SP/GRT 11M21/SP/CAN	Specialization Paper	5	6	90	3 - 3 - 0	40	60	100
11M/DIS	Dissertation	21	12	180		100	100	200
	<b>TOTAL CREDITS</b>	26	18					

## SEMESTER – II ADVANCED ALGEBRA

**PAPER - III : Specialization Paper**  
**Teaching Hours: 90 hrs**

**Course Code : 11M21/SP/AAL**  
**Credits: 5      L-T-P : 3 3 0**

### OBJECTIVES:

To enable students to

- To analyze and understand the concepts of special fields
- To study on representation of one endomorphisms.
- To study and analyze on matrices and linear maps over non-commutative rings
- Analyze and understand theorems on semi simplicity and smith normal form.
- Understand and discuss the algebraic concepts of tensor products.

### COURSE OUTLINE:

#### UNIT I: SPECIAL FIELDS

Ordered domains- the ordered field  $\mathbb{Q}$ -convergence in ordered fields-the real field  $\mathbb{R}$ -valuations and p-adic numbers.

**Chapter 8      Sections: 1,2,4,5,10      (18 hrs)**

#### UNIT II : REPRESENTATION OF ONE ENDOMORPHISM

Representations -decomposition over one endomorphism-the characteristic polynomial.

**Chapter 14      Sections: 1 to 3      (18 hrs)**

#### UNIT III: SEMI SIMPLICITY

Matrices and linear maps over non-commutative rings-conditions defining semi simplicity-the density theorem - semi simple rings -Simple rings - the Jacobson radical, base change and tensor products.

**Chapter 17      Sections: 1to 6      (18 hrs)**

#### UNIT IV: SMITH NORMAL FORM OVER A PID AND RANK

Preliminaries-row module, column module and rank-smith normal form

**Chapter 20      Sections: 1 to 3      (18 hrs)**

**UNIT V: TENSOR PRODUCTS**

Categories and functors - tensor products-module structure of tensor products-tensor product of homomorphisms -tensor product of algebras.

**Chapter 22 Sections: 1 to 5 (18 hrs)**

**BOOKS RECOMMENDED:**

1. Algebra ( 2<sup>nd</sup> Edition ) by Saunders Mac lane and Garrett Birkoff(2017).  
UNIT 1 ( P.NO. 261-267, 269-274,286-292.)
2. Algebra (3<sup>rd</sup> Edition) by Serge Lang (2016).  
UNITS 2 & 3 (P.NO. 553-570, 641-646, 651-654, 657-659)
3. Basic Abstract Algebra by P.B.BATTACHARYA,S.K.JAIN & S.R.NAGPAUL(2009).  
UNITS 4 & 5 ( P.NO. 392-401, 426-437)

**REFERENCE BOOKS :**

1. Higher Algebra by Hall & Knight (2017)
2. Advanced Modern Algebra (2016) ,Second Edition by Joseph J. Rotman  
(Indian Edition)
3. Graduate Texts in Mathematics Advanced Linear Algebra,1999, (Springer ) by Steven Roman.
4. Advanced Algebra (2016),Second Edition by Anthony W. Knapp.

**JOURNALS**

Journal of Algebra

Journal of Algebra and its Applications

Algebra and Logic

Advances in Linear Algebra & Matrix Theory

**WEBSITES & e-LEARNING SOURCES:**

<https://nptel.ac.in/courses/111/102/111102009/>

<https://nitr.edu.in/nptel/courses/video/111106098/115.html>

**COURSE OUTCOME:**

Upon successful completion of Advanced Algebra, Students will be able to:

<b>CO NUMBER</b>	<b>CO STATEMENT</b>
<b>CO 1</b>	Analysis of the study of ordered Domains and convergence in ordered Fields.
<b>CO 2</b>	Study of representations related to one endomorphism.
<b>CO 3</b>	Prepares to the study of semi simplicity.
<b>CO 4</b>	Study and Evaluate Smith Normal form over PID
<b>CO 5</b>	Study of Tensor products

**MAPPING – COURSE OUTCOMES WITH PROGRAMME SPECIFIC OUTCOMES**

<b>CO / PSO</b>	<b>PSO 1</b>	<b>PSO 2</b>	<b>PSO3</b>	<b>PS04</b>	<b>PSO5</b>
<b>CO 1</b>	2	2	1	1	1
<b>CO 2</b>	2	2	1	1	1
<b>CO 3</b>	2	2	1	1	1
<b>CO 4</b>	2	2	1	1	1
<b>CO 5</b>	2	2	1	1	1
<b>Average</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>

**KEY: STRONGLY CORRELATED-3 MODERATELY CORRELATED-2 WEAKLY CORRELATED-1 NO CORRELATION-0**

**TEACHING METHODOLOGY:**

Problem Solving,

Discussions and Interactive Sessions,

Assignments,

Seminars.

**Question Paper Pattern**

<b>Knowledge level</b>	<b>Components</b>	<b>Nature of the Question</b>	<b>Maximum Marks</b>
K <sub>5</sub> , K <sub>6</sub>	Part A	Understanding Description/Problems	(5/8) x 20 =100 Marks

## FUZZY THEORY AND ITS APPLICATIONS

**PAPER III : SPECIALIZATION PAPER COURSE CODE: 11M21/SP/FTA**  
**Teaching Hours : 90 hours Credits: 5 L-T-P : 3 3 0**

### OBJECTIVES:

To enable students to

- Understand the concepts of fuzzy sets and its operations.
- Introduce advanced concepts in Fuzzy Mathematics leading to research.
- Know fuzzy numbers and fuzzy relations.
- Understand the application of fuzzy in various Engineering fields.
- Impart knowledge and skills in fuzzy decision making problems.

### UNIT I: From Classical (Crisp) Sets to Fuzzy Sets: A Grand Paradigm Shift:

Introduction – Crisp Sets: An Overview – Fuzzy Sets: Basic Types – Fuzzy Sets: Basic Concepts – Characteristics and Significance of the Paradigm Shift.

**Fuzzy Sets Versus Crisp Sets:** Additional Properties of  $\alpha$  – cuts – Representations of Fuzzy Sets – Extension Principle for Fuzzy Sets

**Chapter 1 Sections: 1.1 – 1.5,**

**Chapter 2 Sections : 2.1 – 2.3. (17 hrs)**

### UNIT II: Operations on Fuzzy Sets: Types of Operations – Fuzzy Complements.

**Fuzzy Arithmetic:** Fuzzy Numbers – Linguistic Variables – Arithmetic Operations On Intervals – Arithmetic Operations On Fuzzy Numbers – Lattice of Fuzzy Numbers – Fuzzy Equations.

**Chapter 3 Sections: 3.1, 3.2,**

**Chapter 4 Sections : 4.1 – 4.4. (17 hrs)**

### UNIT III: Fuzzy Relations : Fuzzy Ordering Relations – Fuzzy Morphisms – Sup-i

Compositions of Fuzzy Relations – Inf-  $\omega$  ; Compositions of Fuzzy Relations.

**Fuzzy Relation Equations:** Solution Method – Fuzzy Relational Equations Based on sup- i compositions – Fuzzy Relational Equations based on inf-  $\omega$  ; Compositions.

**Chapter 5 Sections: 5.7 – 5.10,**

**Chapter 6 Sections : 6.3 – 6.5. (18 hrs)**

**UNIT IV: Fuzzy Logic:** Classical logic – Multivalued Logics - Fuzzy Propositions – Fuzzy Quantifiers .

**Constructing Fuzzy Sets:** Methods of Construction: An Overview – Direct Methods with One Expert – Indirect Method With One Expert.

**Fuzzy Systems:** Fuzzy Controllers: An Overview – Fuzzy Controllers: An Example.

**Chapter 8 Sections: 8.1 – 8.4,**

**Chapter 10 Sections : 10.2, 10.3, 10.5,**

**Chapter 12 Sections : 12.2 &12.3 (20 hrs)**

**UNIT V: Fuzzy Decision Making:** General Discussion – Individual Decision Making – Multiperson Decision Making – MultiCriteria Decision Making – MultiStage Decision Making – Fuzzy Ranking Methods – Fuzzy Linear Programming.

**Chapter 15 Sections: 15.1 – 15.7. (18 hrs)**

**BOOKS RECOMMENDED:**

George Klir and Bo Yuan, Fuzzy Sets And Fuzzy Logic – Theory and Applications, 2016, PHI Learning Pvt Ltd, New Delhi.

**REFERENCE BOOKS:**

1. Ahmad M. Ibrahim, Introduction to Applied Fuzzy Electronics. New Delhi : Prentice Hall India, 1997.
2. Bart.Kosko, Neural Networks and fuzzy systems, New Delhi :Prentice-Hall of India, 2003.
3. George Klir J. and Folger Tina A., Fuzzy Sets, Uncertainty and Information. New Delhi: Prentice Hall India, 2004.
4. Toshiro Terano, Asai Kiyoji, Sugeno Michio, Applied Fuzzy Systems. New York : A.P. Professional, 1994.
5. Zadeh Lotfi A., Fuzzy Sets and Their Applications to Cognitive and Decision Processes, New York, Academic Press, 1975.

**PERIODICALS:**

Journal of Intelligent & Fuzzy Systems  
 International Journal of Fuzzy System and Applications  
 International Journal of Fuzzy Computation and Modelling  
 The Mathematics Intelligencer  
 Mathematics News Letter

**WEBSITES AND E-LEARNING SOURCES :**

1. <https://www.britannica.com/science/fuzzy-logic>
2. [https://www.tutorialspoint.com/fuzzy\\_logic/fuzzy\\_logic\\_decision\\_making.html](https://www.tutorialspoint.com/fuzzy_logic/fuzzy_logic_decision_making.html)
3. <https://www.sjsu.edu/faculty/watkins/fuzzysets.html>

**COURSE OUTCOME :**

Upon completion of Fuzzy theory and its applications, Student will be able to

<b>CO NUMBER</b>	<b>CO STATEMENT</b>
<b>CO 1</b>	Effectively uses fuzzy sets from ordinary sets.
<b>CO 2</b>	Recognize fuzzy numbers as a foundation of fuzzy sets and fuzzy Mathematics.
<b>CO 3</b>	Represent the strength of association between elements of the two sets.
<b>CO 4</b>	Predict different kinds of fuzzy logic using fuzzy proposition and quantifier.
<b>CO 5</b>	Identify the formulation and solutions of design problems that are developed using fuzzy theory.

**MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME**

<b>CO / PSO</b>	<b>PSO 1</b>	<b>PSO 2</b>	<b>PSO3</b>	<b>PS04</b>	<b>PSO5</b>
<b>CO 1</b>	3	2	3	1	3
<b>CO 2</b>	2	1	3	2	2
<b>CO 3</b>	2	2	1	2	3
<b>CO 4</b>	1	1	1	1	2
<b>CO 5</b>	1	1	3	1	2
<b>Average</b>	<b>1.8</b>	<b>1.4</b>	<b>2.2</b>	<b>1.4</b>	<b>2.4</b>



**KEY: STRONGLY CORRELATED-3 MODERATELY CORRELATED-2 WEAKLY  
CORRELATED-1 NO CORRELATION-0**

**TEACHING METHODOLOGY:**

Lecture (chalk and talk),

Problem Solving,

Discussion and Interactive session,

Assignment,

Seminar.

**Question Paper Pattern**

Knowledge level	Components	Nature of the Question	Maximum Marks
K <sub>5</sub> , K <sub>6</sub>	Part A	Understanding Description/Problems	(5/8) x 20 =100 Marks

## GRAPH THEORY

**PAPER III : Specialization Paper**  
**Teaching Hours : 90 Hours**

**Course Code: 11M21/SP/GRT**  
**Credits: 5      L-T-P : 3 3 0**

### OBJECTIVES:

This course will enable the students

1. To know about Matchings, Factors and their related theorems
2. To understand Colourings in graphs.
3. To identify independent sets and cliques.
4. To study about directed graphs and its applications.
5. To explore and study more about the nature and properties of Planar graphs and Networks.

### COURSE OUTLINE:

#### UNIT I: Matching and factors

Maximum Matching, Hall's matching condition, Min-Max theorems,  
 Tutte's 1-factor theorem

**Book 1: Chapter 3: 3.1, 3.3 (15 hours)**

#### UNIT II: Colouring of graphs:

Definitions and examples, upper bounds, Brook's theorem Edges and cycles  
 Edge colourings, Hamiltonian cycles (Necessary and Sufficient conditions )  
 Tait's Theorem.

**Book 1: Chapter 5 :5.1 ,  
 Chapter 7 : Section 7.1, 7.2, 7.3 (20 hours)**

#### UNIT III: Independent Sets and Cliques

Independent sets, Ramsey's theorem, Turan's theorem

**Book 2: Chapter 7 Sections 7.1, 7.2, 7.3 (15 hours)**

#### UNIT IV: Directed Graphs

Directed Graphs, Directed paths, Directed cycles

**Book 2:Chapter10 Sections 10.1 - 10.4 (20 hours)**

#### UNIT V: Networks

Algorithm -Networks: Flows, cuts, The Max –flow Min-cut Theorem,  
 Mengers theorems., Feasible flows.

**Book 2 : Chapter 11 Sections 11.1-11.5 (20 hours)**

**BOOKS RECOMMENDED :**

**Book 1:** Douglas B. West, *Introduction to Graph Theory* –Second edition, PHI learning pvt. ltd, 2011.

**Book 2:** Graph Theory and its applications – J. A. Bondy and U. S. R. Murty

**REFERENCE BOOKS :**

1. A. Gibbons, *Algorithmic Graph Theory*, Cambridge University Press, Cambridge, 1989.
2. S. A. Choudum, *A First Course in Graph Theory*, MacMillan India Ltd. 1987.
3. Richard J. Trudeau, *Introduction to Graph Theory* (Dover Books on Mathematics) Paperback – 9 Feb 1994.
4. Gary Chartrand, Ping Zhang, *A First Course in Graph Theory*, Courier Corporation, 2012.

**PERIODICALS:**

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

**WEBSITES AND E-LEARNING SOURCES :**

<https://www.nptel.ac.in/courses/111/106/111106102/>

<https://www.nptel.ac.in/courses/111/106/111106050/>

<https://www.nptel.ac.in/courses/128/106/128106001/>

<https://www.britannica.com/topic/graph-theory>

**COURSE OUTCOME:**

Upon completion of Graph Theory, this course will enable the students

<b>CO NUMBER.</b>	<b>CO STATEMENT</b>	<b>Knowledge Level</b>
<b>CO 1</b>	To analyze the concept Matchings and factors.	K <sub>5</sub> , K <sub>6</sub>
<b>CO 2</b>	To examine and identify the chromatic number of various graphs.	K <sub>5</sub> , K <sub>6</sub>
<b>CO 3</b>	To apply the analytical techniques and theoretical knowledge in solving many real life problems. To prove theorems related to independent sets and Cliques.	K <sub>5</sub> , K <sub>6</sub>
<b>CO 4</b>	To solve and analyze the properties and theorems related to Directed graphs.	K <sub>5</sub> , K <sub>6</sub>
<b>CO 5</b>	To apply Euler's formula and Four Colour Conjecture in various problems and in many practical situations. To analyse about network and related problems.	K <sub>5</sub> , K <sub>6</sub>

**MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME**

<b>CO / PSO</b>	<b>PSO 1</b>	<b>PSO 2</b>	<b>PSO 3</b>	<b>PSO 4</b>	<b>PSO 5</b>
<b>CO 1</b>	2	1	2	3	1
<b>CO 2</b>	2	1	2	3	1
<b>CO 3</b>	2	1	2	3	1
<b>CO 4</b>	2	1	2	3	1
<b>CO 5</b>	2	1	2	3	1
<b>Average</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>1</b>

**KEY: STRONGLY CORRELATED-3 MODERATELY CORRELATED-2 WEAKLY CORRELATED-1 NO CORRELATION-0**

**TEACHING METHODOLOGY:**

Problem Solving

Group Discussion- Seminar - Peer Learning.

**Question Paper Pattern**

<b>Knowledge level</b>	<b>Components</b>	<b>Nature of the Question</b>	<b>Maximum Marks</b>
K <sub>5</sub> , K <sub>6</sub>	Part A	Understanding Description/Problems	(5/8) x 20 =100 Marks

## COMPLEX ANALYSIS

**PAPER III : Specialization Paper**  
**Teaching Hours : 90 hours**

**COURSE CODE : 11M21/SP/CAN**  
**Credits: 5 L-T-P : 3 3 0**

### OBJECTIVES:

#### To enable students to

- Understand the basic concepts of univalent functions.
- Analyse and understand the concepts and theorems on univalent functions.
- Understand the concepts of subordination
- Understand the properties of Extremal functions.
- Equip the students in pursuing research in Mathematics.

### COURSE OUTLINE:

**UNIT I : ELEMENTARY THEORY OF UNIVALENT FUNCTIONS :** Introduction – The Area Theorem – Growth and Distortion theorems – Coefficient estimates – Convex and Starlike functions – Close to convex functions – Spirallike functions.

**Chapter 2 : 2.1 to 2.7** **(15 hrs)**

**UNIT II :** Growth and integral means – Odd univalent functions – Asymptotic Bieberbach Conjecture .Caratheodory Convergence Theorem, Loewner’s Differential Equation.

**Chapter 2 : 2.10 to 2.12**

**Chapter 3: 3.1 and 3.2** **(15 hrs)**

### UNIT III : GENERALIZATIONS OF THE AREA PRINCIPLE :

Faber polynomials – Polynomial Area theorem – The Grunsky Inequalities – Inequalities of Goluzin and Lebedev – Unitary matrices – The Fourth Coefficients – Coefficient problem in the class  $\Sigma$  , Exponentiation of Power series, Reformulation of the Grunsky Inequalities.

**Chapter 4 : 4.1 to 4.7**

**Chapter 5: 5.1 and 5.2** **(20 hrs)**

### UNIT IV : SUBORDINATION :

Basic principles – Coefficient inequalities – Sharpened Forms of the Schwarz Lemma – Majorization – Univalent Subordinate Functions.

**Chapter 6 : 6.1 to 6.5** **(20 hrs)**

**UNIT V : GENERAL EXTREMAL PROBLEMS :**

Functionals on Linear spaces – Representation of Linear functional – Extreme points and Support points – Properties of Extremal functions – Extreme points of  $S$  – Extreme points of  $\Sigma$  .

**Chapter 9 : 9.1 to 9.6**

**(20 hrs)**

**BOOKS RECOMMENDED :**

Univalent Functions , P.L.Duren, Springer-Verlag, Newyork.

**REFERENCE BOOKS :**

1. Univalent Functions Vol I and Vol II By Goodman . A.W.
2. Conformal Mapping by Z.Nehari,McGraw-Hill ,New York (1952).
3. Handbook of Complex Analysis: Geometric Function theory Vol -1, R.Kuhnau, Elsevier Publications.
4. Complex Analysis (Third Edition), Serge Lang, Springer.
5. Univalent Functions and Teichmuller Spaces,Olli Lehto, Springer.

**PERIODICALS:**

The Mathematics Intelligencer.

Mathematics Newsletters

**WEBSITES & E-LEARNING SOURCES:**

<https://terrytao.wordpress.com/tag/univalent-functions/>

<https://cuhkmath.wordpress.com/2012/03/04/principle-of-subordination/>

**COURSE OUTCOME:**

Upon completion of this course Complex Analysis the students will be able to

<b>CO NUMBER</b>	<b>CO STATEMENT</b>
<b>CO 1</b>	Compare the starlike and convex functions
<b>CO 2</b>	Apply the concepts of odd univalent functions
<b>CO 3</b>	Analyse the concepts of Faber polynomial and Grunsky inequalities
<b>CO 4</b>	Discuss the basic principle of subordination and Schwarz lemma.
<b>CO 5</b>	Discuss the properties of Extremal functions and compute general extremal problems

**MAPPING – COURSE OUTCOME WITH PROGRAMME SPECIFIC OUTCOME**

<b>CO / PSO</b>	<b>PSO 1</b>	<b>PSO 2</b>	<b>PSO3</b>	<b>PS04</b>	<b>PSO5</b>
<b>CO 1</b>	2	2	3	3	2
<b>CO 2</b>	3	2	3	3	2
<b>CO 3</b>	3	3	2	2	3
<b>CO 4</b>	2	2	2	2	3
<b>CO 5</b>	3	3	3	3	2
<b>Average</b>	<b>2.6</b>	<b>2.4</b>	<b>2.6</b>	<b>2.6</b>	<b>2.4</b>

**KEY:** STRONGLY CORRELATED-3 MODERATELY CORRELATED-2 WEAKLY CORRELATED-1 NO CORRELATION-0

**TEACHING METHODOLOGY:**

Lecture (chalk and talk),

Problem Solving,

Discussion and Interactive session,

Assignment,

Seminar.

**Question Paper Pattern**

<b>Knowledge level</b>	<b>Components</b>	<b>Nature of the Question</b>	<b>Maximum Marks</b>
K <sub>5</sub> , K <sub>6</sub>	Part A	Understanding Description/Problems	(5/8) x 20 =100 Marks