Program
Master of Science
MATHEMATICS

(Revised with effect from 2016-17 AY onwards)

Table of Contents

Programme Outcomes

PO1. Scientific Knowledge and Pursuit: Gain and apply knowledge of basic scientific and mathematical fundamentals, to develop deeper understanding Nature and apply it to solve problems in respective fields of specialization.

PO2. Theoretical Methods & Problem Analysis: Develop analytical skills to analyze complex phenomena using first principles enabling one to identify underlying structure.

PO3. Experimental Skills and Development of solutions: Use of research-based knowledge and research methods including design of physical/computational experiments, Design of solutions for complex chemistry/physics/ mathematics problems and evolve procedures appropriate to a given problem.

PO4. Computational, Numerical and Data Analysis: Numerical analysis and simulation modeling and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Analytical Tool Usage: Select, and apply appropriate techniques, resources, and modern analytical tools and software.

PO6. Scientific Communication: Communicate orally and in writing on complex scientific activities with peers, educators, science community, and with society at large, such as being able to comprehend and write effective scientific articles, make effective presentations, and give and receive clear instructions.

PO7. Individual and team work: Think critically and work independently, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO8. Project management and finance: Demonstrate knowledge and understanding of the scientific and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO9. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of scientific practice.

PO10. The scientist and society: Apply reasoning through the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional scientific practice.

PO11. Environment and sustainability: Understand the impact of scientific processes in societal and environmental contexts, and demonstrate the knowledge, and need for sustainable development.

PO12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological changes for up-to-date research and teaching methods.

Programme Specific Outcomes:

MSc Mathematics

PSO1. Understand the nature of abstract mathematics and explore the concepts in further details

PSO2. Pursue research in challenging areas of pure/applied mathematics

PSO3. Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in society.

PSO4. Acquire deep knowledge of different mathematical disciplines so that they can qualify NET/ GATE examination

PSO5. Generate publications in reputed mathematical journals.

PSO6. Work as a Mathematics professional, and qualify for training as scientific researcher.

Curriculum Structure

MASTER OF SCIENCE

MATHEMATICS

For 2016 admissions onwards

GENERAL INFORMATION

Code Numbering:

Each course is assigned an 8-character Code number. The first two digits indicate the year of curriculum revision. The next three letters indicate the Department offering the course. The last three digits are unique to the course – the first digit indicates the level of the course (100, 200, 300, 400 etc.); the second digit indicates the type of the course, viz. 0, 1 and 2 indicate the core courses; 3,4,5,6 and 7 indicate the Elective courses; 8 indicates the Lab. or practical-based courses and 9 indicates Projects**.**

ABBREVIATIONS USED IN THE CURRICULUM:

Cat - Category
Cr - Credits
ES - Exam Slot
L - Lecture

P - Practical
T - Tutorial

DISCIPLINES

AVP - Amrita Values Programmes
BUS - Business Management
CHY - Chemistry
CMJ - Communication and Journalism
COM - Commerce
CSA - Computer Science and Applications
CSN - Computer Systems and Network
CUL - Cultural Education
ECO - Economics
ELL - English Language and Literature
ENG - English
ENV - Environmental Sciences
FNA - Fine Arts
HIN - Hindi
KAN - Kannada
LAW - Law
MAL - Malayalam
MAT - Mathematics
MCJ - Mass Communication and Journalism
OEL - Open Elective

PHY - Physics
SAN - Sanskrit
SSK - Soft Skills
SWK - Social Work
TAM - Tamil

CURRICULUM
M Sc–Mathematics 2016

Code No.	Course Title	L T P	Cr	EMployability	Code No.	Course Title	L T P	Cr	Value add
SEMESTER 1					**SEMESTER 2**				
15MAT501	Advanced Algebra	4 0 0	4		15MAT503	Topology	4 0 0	4	
15MAT502	Advanced Real Analysis	4 0 0	4		15MAT512	Functional Analysis	4 0 0	4	
15MAT511	Advanced Complex Analysis	4 0 0	4		15MAT513	Graph Theory	4 0 0	4	
15MAT504	Ordinary Differential Equations	4 0 0	4		15MAT514	Partial Differential Equations	4 0 0	4	
	Elective Paper I	3 0 0	3			Elective Paper II	3 0 0	3	
15CUL501	Cultural Education	2 0 0	P/F		15AVP501	Amrita Value Programme	1 0 0	1	
							20 0 0 20		
	TOTAL		**21**			TOTAL		**20**	
SEMESTER 3					**SEMESTER 4**				
15MAT601	Advanced Topology	4 0 0	4			Elective Paper IV	3 0 0	3	
15MAT603	Measure and Integration	4 0 0	4			Elective Paper V	3 0 0	3	
15MAT604	Operator Theory	4 0 0	4		15MAT696	Dissertation		10	
15MAT605	Differential Geometry	4 0 0	4				6 0 0 6		
	Elective Paper III	3 0 0	3			TOTAL		**16**	
	Free/Open Elective / Live-in-Lab	2 0 0	2						
		21 0 0 21							
	TOTAL		**21**						
						TOTAL Credits for the programme	**78**		
	ELECTIVES(Any five-minimum 3 from a single stream)								
	Algebra Stream					**Analysis Stream**			
15MAT631	Algebraic Geometry	3 0 0	3		15MAT641	Fixed Point Theory	3 0 0	3	
15MAT632	Algebraic Topology	3 0 0	3		15MAT642	Fractals	3 0 0	3	
15MAT633	Coding Theory	3 0 0	3		15MAT643	Harmonic Analysis	3 0 0	3	
15MAT634	Commutative Algebra	3 0 0	3		15MAT644	Nonlinear Partial Differential Equations	3 0 0	3	

	15MAT635	Lie Algebra	3 0 0	3			15MAT645	Wavelet Analysis	3 0 0	3		
	15MAT636	Theory of Manifolds	3 0 0	3			15MAT646	Mathematical Physics	3 0 0	3		
	15MAT637	Linear Algebra and its Applications	3 0 0	3								
		Statistics Stream						**Fluid Mechanics Stream**				
	15MAT651	Queuing Theory and Inventory Control Theory	3 0 0	3			15MAT661	Advance Boundary Layer Theory	3 0 0	3		
	15MAT652	Random Process	3 0 0	3			15MAT662	Computational Fluid Dynamics	3 0 0	3		
	15MAT653	Statistical Pattern Classifications	3 0 0	3			15MAT663	Finite Element Methods	3 0 0	3		
	15MAT654	Statistical Quality Control and Six Sigma Quality Analysis	3 0 0	3			15MAT664	Magneto-Hydro Dynamics	3 0 0	3		
	15MAT655	Theory of Sampling and Design of Experiments	3 0 0	3			15MAT665	Mathematical Foundations of Incompressible Fluid Flow	3 0 0	3		
	15MAT656	Time Series Analysis	3 0 0	3			15MAT666	Introduction to Fluid Dynamics	3 0 0	3		
		Computer Stream										
	15MAT671	Advanced Data Structures and Algorithms	3 0 0	3								
	15MAT672	Advanced Graph Theory	3 0 0	3								
	15MAT673	Computer Aided Design of VLSICircuits	3 0 0	3								
	15MAT674	Cryptography	3 0 0	3								
	15MAT675	Fuzzy Sets and its Applications	3 0 0	3								
	15MAT676	Introduction to Soft Computing	3 0 0	3								
	15MAT677	Object-Oriented Programming and Python	3 0 0	3								

OPEN ELECTIVES

Course code	Course Title	L – T – P	Cr.	ES
15OEL231	Advertising	3 0 0	3	J
15OEL232	Basic Statistics	3 0 0	3	J
15OEL233	Citizen Journalism	3 0 0	3	J
15OEL234	Creative Writing for Beginners	3 0 0	3	J
15OEL235	Desktop Support and Services	3 0 0	3	J
15OEL236	Development Journalism	3 0 0	3	J
15OEL237	Digital Photography	3 0 0	3	J
15OEL238	Emotional Intelligence	3 0 0	3	J
15OEL239	Essence of Spiritual Literature	3 0 0	3	J
15OEL240	Film Theory	3 0 0	3	J
15OEL241	Fundamentals of Network Administration	3 0 0	3	J
15OEL242	Gender Studies	3 0 0	3	J
15OEL243	Glimpses of Indian Economy and Polity	3 0 0	3	J
15OEL244	Graphics and Web-designing Tools	3 0 0	3	J
15OEL245	Green Marketing	3 0 0	3	J
15OEL246	Healthcare and Technology	3 0 0	3	J
15OEL247	History of English Literature	3 0 0	3	J
15OEL248	Indian Writing in English	3 0 0	3	J
15OEL249	Industrial Relations and Labour Welfare	3 0 0	3	J
15OEL250	Introduction to Ancient Indian Yogic and Vedic Wisdom	3 0 0	3	J
15OEL251	Introduction to Computer Hardware	3 0 0	3	J
15OEL252	Introduction to Event Management	3 0 0	3	J
15OEL253	Introduction to Media	3 0 0	3	J
15OEL254	Introduction to Right to Information Act	3 0 0	3	J
15OEL255	Introduction to Translation	3 0 0	3	J
15OEL256	Linguistic Abilities	3 0 0	3	J
15OEL257	Literary Criticism and Theory	3 0 0	3	J
15OEL258	Macro Economics	3 0 0	3	J
15OEL259	Managing Failure	3 0 0	3	J
15OEL260	Media Management	3 0 0	3	J
15OEL261	Micro Economics	3 0 0	3	J
15OEL262	Micro Finance, Small Group Management and Cooperatives	3 0 0	3	J
15OEL263	Negotiation and Counselling	3 0 0	3	J
15OEL264	New Literatures	3 0 0	3	J
15OEL265	Non-Profit Organisation	3 0 0	3	J
15OEL266	Personal Effectiveness	3 0 0	3	J
15OEL267	Perspectives in Astrophysics and Cosmology	3 0 0	3	J
15OEL268	Principles of Marketing	3 0 0	3	J
15OEL269	Principles of Public Relations	3 0 0	3	J
15OEL270	Science, Society and Culture	3 0 0	3	J
15OEL271	Statistical Analysis	3 0 0	3	J
15OEL272	Teamwork and Collaboration	3 0 0	3	J
15OEL273	The Message of Bhagwad Gita	3 0 0	3	J

15OEL274	Understanding Travel and Tourism	3 0 0	3	J
15OEL275	Videography	3 0 0	3	J
15OEL276	Vistas of English Literature	3 0 0	3	J
15OEL277	Web-Designing Techniques	3 0 0	3	J

Evaluation Scheme and Grading System

R.13 Assessment Procedure

R.13.1The academic performance of each student in each course will be assessed on the basis of Internal Assessment (including Continuous Assessment) and an end-semester examination.

Normally, the teachers offering the course will evaluate the performance of the students at regular intervals and in the end-semester examination.

R.13.2 In theory courses (that are taught primarily in the lecture mode), the weight for the Internal Assessment and End-semester examination will be 50:50. The Internal assessment in theory courses shall consist of at least two periodical tests, weekly quizzes, assignments, tutorials, viva-voce etc. The weight for these components, for theory-based courses shall be 20 marks for the Continuous assessment, comprising of Quizzes, assignments, tutorials, viva-voce, etc. and 15 marks each for both the Periodical Tests.

At the end of the semester, there will be an end-semester examination of three hours duration, with a weight of 50 marks, in each lecture-based subject.

R.13.3 In the case of laboratory courses and practical, the relative weight for internal assessment and End-semester examination will be 80:20.The weight for the components of internal assessment will be decided by the course committee/class committee at the beginning of the course.

Evaluation pattern for course having both Theory and Lab components:

Courses having only one hour per week for lecture/tutorial, be treated as a Lab. course, for evaluation purposes; and evaluation pattern will be 80 marks for continuous assessment of lab work and 20 marks for end-semester lab examination.

Courses having two hours per week for theory and/or tutorials, be given a weight of 60 marks and 40 marks for the Theory and Lab components, respectively; The Lab. component evaluation will be based on continuous evaluation, without any end-semester practical evaluation. 10 marks will be for continuous assessment of the theory portion, 10 marks for each of the two periodical tests, 30 marks for the theory end-semester examination and 40 marks for continuous assessment of lab work and

Courses having three hours per week for theory and/or tutorials, be given a weight of 70 marks and 30 marks for the Theory and Lab components, respectively; The Lab component evaluation will be based on continuous evaluation, without any end-semester practical evaluation. 15 marks will be for continuous assessment of the theory portion, 10 marks for each of the two periodical tests, 35 marks for the theory end-semester examination and 30 marks for continuous assessment of lab work.

R.13.4 It is mandatory that the students shall appear for the end-semester examinations in all theory and weight courses, for completion of the requirements of the course. Those who do not appear in the end-semester examinations will be awarded ‘F’ grade, subject to meeting the attendance requirement.

At the end of a semester, examinations shall be held for all the subjects that were taught during that semester and those subjects of the previous semester s for which the student s shall apply for supplementary examination, with a prescribed fee.

R.13.5 PROJECT WORK: The continuous assessment of project work will be carried out as decided by the course committee. At the completion of the project work, the student will submit a bound volume of the project report in the prescribed format. The project work will be evaluated by a team of duly appointed examiners.

The final evaluation will be based on the content of the report presentation by student and a viva-voce examination on the project. There will be 40% weight for continuous assessment and the remaining60% for final evaluation.

If the project work is not satisfactory he/she will be asked to continue the project work and appear for assessment later.

R.14 PUBLICATION / INTERNSHIP

R.14.1All students, if they are to be considered for award of the Degree at the time of graduation, are required to have published ONE paper in Scopus-indexed Journal/Conference.

R.14.2Additional 5-10 marks will be awarded for each Publication, subject to a maximum of ONE paper per semester.

The additional marks shall be awarded in the semester in which the paper is published or accepted for publication, if applied for, within10 days of the publication of results of the concerned semester. The additional marks can be awarded to any course(s) where the student has to improve his/her grade.

R.14.3All publications shall be in Scopus-indexed Journals/Conferences and shall be as per the guidelines prescribed by the University.

R.14.4Students who have undergone Internship at reputed organizations or National / International Institutions, with the prior approval of the concerned Departmental Chairperson and the Head of the School, may be considered for waiver of the requirement of publication, for the award of Distinction. However, the decision of the Departmental Chairperson and the Head of the School, in this regard, shall be final.

R.16 Grading

R.16.1 Based on the performance in each course, a student is awarded at the end of the semester, a letter grade in each of the courses registered.

Letter grades will be awarded by the Class Committee in its final sitting, without the student representatives. The letter grades, the corresponding grade points and the ratings are as follows:

Letter Grade	Grade Points	Ratings
0	10.00	Outstanding
A+	9.50	Excellent
A	9.00	Very Good
B+	8.00	Good
B	7.00	Above Average
C	6.00	Average
P	5.00	Pass
F	0. 00	Fail
FA	0. 00	Failed due to insufficient attendance

I	0. 00	Incomplete (awarded only for Lab courses/ Project / Seminar)
W		Withheld

R.16.2 ‘FA‘grade once awarded stays in the record of the student and is replaced with the appropriate grade when he/she completes the course successfully later.

Students who have secured an ‘FA’ in a course must re-register for the course or register for the course, if offered, under run-time re-do mode.

R.16.3 A student who has been awarded ‘I’ Grade in a Lab course, due to reasons of not completing the Lab., shall take up additional Lab. whenever offered next and earn a pass grade, which will be reflected in the next semester’s grade sheet.

The ‘I’ grade, awarded in a Project/Seminar course, will be subsequently changed into appropriate grade, when the student completes the requirement during the subsequent semester. If he/she does not complete it in the next semester, it will be converted to ‘F’ grade.

R.16.4 A student is considered to have successfully completed the course and earned the credit, if he/she scores a letter grade ‘P’ or better in that course.

R.21 Semester Grade Point Average (SGPA)

On completion of a semester, each student is assigned Semester Grade Point Average (SGPA) which is computed as below for all courses registered by the student during that semester.

Semester Grade Point Average = Σ (Ci x Gpi) / Σ Ci

where Ci is the credit for ith course in that semester and Gpi is the grade point for that course.

The summation is over all the courses registered by the student during the semester, including the failed courses. The SGPA is rounded off to two decimals.

R.22 Cumulative Grade Point Average (CGPA)

The overall performance of a student at any stage of the Degree programme is evaluated by the Cumulative Grade Point Average (CGPA) up to that point of time.

Cumulative Grade Point Average =Σ (Ci x Gpi) / Σ Ci

where Ci is the credit for ith course in any semester and Gpi is the grade point for that course.

The summation is over all the courses registered by the student during all the semesters up to that point of time, including the failed courses. The CGPA is also rounded off to two decimals.

R.23 Ranking

The ranking of the students in a batch at any intermediate or final stage is based on CGPA. Only those students who have passed all courses up to that stage in the first attempt are considered for ranking. Students are eligible for final ranking, only if the programme is completed within the normal duration, i.e., within two years from joining the programme.

R.24 Classification of successful candidates:

R.24.1 A student shall be considered to have successfully completed the programme, if he/she has:

i) registered and successfully completed all the core courses, electives and projects as mentioned in the

curriculum;
ii) earned the required minimum number of credits as specified in the curriculum corresponding to the programme, within the stipulated time;
iii) published a paper at a Scopus-indexed Journal/Conference.

R.24.2 Candidates who have successfully completed the programme, within a period of four semesters from entering the programme, shall be classified as follows:
Candidates securing a CGPA of 8.00 and above – FIRST CLASS WITH DISTINCTION *
Candidates securing a CGPA between 6.50 and 7.99 – FIRST CLASS
and the same be mentioned in the Degree certificate;
(*subject to satisfying the condition mentioned at R.14.1 and having passed all the courses, in the first attempt, in four semesters, from the date of joining the programme)
If the programme is completed after four semesters of study, the candidates securing even a CGPA of 8.00 and above, shall be classified to have completed the programme, only with FIRST CLASS.

Course Objectives, Course Outcomes, Syllabus

Basic Analysis and Algebra

Semester1 (Bridge Course)

Definitions, examples and important theorems without proof.

Limits and Continuity: Examples of continuous functions – Continuity and inverse images of open or closed sets – Functions continuous on compact sets – Topological mappings (homeomorphisms) - Bolzano's theorem – Connectedness – Components of a metric space – Arcwise connectedness – Uniform continuity – Uniform continuity and compact sets –Fixed-point theorem for contractions – Discontinuities of real-valued functions – Monotonic functions. (Text book 1: Sec. 4.11 to 4.23)

Derivatives: Introduction – Definition of derivative –Derivatives and continuity – Algebra of derivatives – The chain rule – One-sided derivatives and infinite derivatives – Functions with nonzero derivative – Zero derivatives and local extrema – Rolle's theorem – The Mean-value theorem for derivatives – Intermediate-value theorem for derivatives – Taylor's formula with remainder – Derivatives of vector-valued functions – Partial derivatives – Differentiation of functions of a complex variable – The Cauchy-Riemann equations. (Text book 1. Sec. 5.1 to 5.16

Groups: Definition of Groups, Subgroups and Factor Groups, Lagrange's Theorem, Homomorphisms, Normal Subgroups. Quotients of Groups. Basic Examples of Groups including Symmetric Groups, Matrix Groups, Groups of Rigid Motions of a Plane, Finite Groups of Motions. Automorphisms, Cayley's Theorem, Permutation Groups, Counting Principles, Sylow's Theorems. (Text book 2-Sec. 2.1 to 2.12)

Rings: Definition of Rings, Examples including Polynomial Rings, Formal Power Series Rings, Matrix Rings and Group Rings. Commutative Rings, Integral Domain, Division Ring, Characteristics of an Integral domain, Homomorphisms, Ideals, Quotient Rings. (Text book 2 Sec. 3.1 to 3.4)

Text Books:

1. 1. Mathematical Analysis by Tom M. Apostol, Second Edition, Narosa publishing house, New Delhi,1989.
2. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

References:

1. Introduction to Real Analysis, by Robert Gardner Bartle, Donald R. Sherbert, , Fourth Edition, John Wiley and Sons, 2011.
2. Principles of Mathematical Analysis by Rudin.W, Third Edition, McGraw-Hill

   International Editions, 1976.

3. Garrett Birkoff and Saunders Mac Lane, 'A Survey of Modern Algebra', Universities Press, 2003.

4.M.Artin, 'Algebra', Prentice Hall inc., 1994.

15MAT501 Advanced Algebra 3 1 0 4

Course Outcome:

CO-1: To derive the class equation and use it in various counting problems. To derive Cauchy's/ Sylow's theorem for general groups.

CO-2: To understand direct product and to apply Sylow's theorem to Classify finite Abelian Groups.

CO-3: To understand polynomial rings over rational fields and identify irreducible polynomials through standard theorems.

CO-4: To study in details special cases of integral domains. To familiarize the concept of Grobner Bases and its applications.

CO-5: To familiarize Galois theory and its use in analyzing the solvability by radicals of polynomial equations.

Review: Groups and Rings

Groups: Direct products, Finite Abelian Groups. (Sec. 2.13 and 2.14).

Rings: The Field of Quotients of an Integral Domain, Euclidean Rings, Polynomial Rings, Polynomial Rings over the Rational Field, Polynomial Rings over Commutative Rings. (Sec. 3.5 to 3.11).

Fields: Classical Ruler and Compass Constructions, Roots of Polynomials, Remainder Theorem, Splitting Field and its Uniqueness, Distinct and Multiple Roots, Simple Extension of a Field, The Elements of Galois Theory, Solvability by Radicals, Galois Groups over the Rationals. (Sec. 5.3 to 5.8).

Text Books:

1. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

References

1. Garrett Birkoff and Saunders Mac Lane, 'A Survey of Modern Algebra', Universities Press, 2003.
2. M.Artin, 'Algebra', Prentice Hall inc 1994.

Evaluation Pattern – R.13 & R.16

Learning Outcome

Requirement for teaching Profession. This components are used in equations :To derive the class equation and use it in various counting problems. To derive Cauchy's/ Sylow's theorem for general groups. To understand direct product and to apply Sylow's theorem to classify finite Abelian Groups. To understand polynomial rings over rational fields and identify irreducible polynomials through standard theorems. To study in details special cases of integral domains. To familiarize the concept of Grobner Bases and its applications. To familiarize Galois theory and its use in analyzing the solvability by radicals of polynomial equationsich shows relationship between particular numbers. This form of Math touches modern life.

15MAT502 Advanced Real Analysis 4 0 0 4

Course Outcome:

CO1- Understanding Riemann-Stieltjes Integral and applying it to evaluate length of the Rectifiable curves

CO2- Understanding Equicontinuous Families of Functions and The Stone-Weierstrass Theorem.

CO3- Understanding special functions and algebraic completeness of the complex field

CO4- Applying the concept of derivatives in functions of several variables.

CO5- Understanding Contraction principle, The inverse function theorem, The implicit function theorem.

Unit I : Functions of Bounded Variation and Rectifiable Curves:

Introduction, Properties of monotonic functions, Functions of bounded variation, Total Variation, Additive property of total variation, Total variation on $[a, x][a, x]$ as a function of xx, Functions of bounded variation expressed as the difference of increasing functions, Continuous functions of bounded variation.

(Chapter 6 : 6.1-6.8)

Unit II :

Riemann-Stieltjes Integral: Definition and Existence of the Integral, Properties of the Integral, Integration and Differentiation, Integration of vector-valued functions, Rectifiable curves.

Sequences and Series of Functions: Sequence of functions and its point-wise limit, Discussion of main problems, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation, Equicontinuous Families of Functions, The Stone-Weierstrass Theorem.

Some Special Functions: Introduction to power series, The Exponential and Logarithmic Functions, The Trigonometric Functions, The Algebraic Completeness of the Complex Field, Fourier series, Gamma function and its properties.

Text Book:

1. **Mathematical Analysis** by Tom M. Apostol, Second Edition, Narosa publishing house, New Delhi,1989.

Reference Books:

1. **Introduction to Real Analysis**, by Robert Gardner Bartle, Donald R. Sherbert, , Fourth Edition**,** John Wiley and Sons, 2011.

2. **Principles of Mathematical Analysis** by Rudin.W, Third Edition, McGraw-Hill

International Editions, 1976.

3. **Real Analysis** by H.L. Royden and P.M.Fitzpatrick. Fourth Edition. Pearson Education Asia Limited, 2010.

Evaluation Pattern – R.13 & R.16

Learning Outcomes Requirement for teaching Profession. Necessary background for measure theory. It is concerned with studying the behavior and properties of functions, sequencs and sets. This components are useful for :Understanding Riemann-Stieltjes Integral and applying it to evaluate length of the Rectifiable curves Understanding Equicontinuous Families of Functions and The Stone-Weierstrass Theorem.Understanding special functions and algebraic completeness of the complex field. Applying the concept of derivatives in functions of several variables. Understanding Contraction principle, The inverse function theorem, The implicit function theorem.

15MAT503 Basic Topology 3 1 0 4

Course Outcome:

CO1:To introduce the concept of Metric spaces as a generalization of the analysis on the real line at a level and depth appropriate for introducing Topological spaces and for providing a prerequisite for the forth coming courses like Differential Geometry, Functional Analysis, Complex Analysis etc..

CO2To present an introduction to the field of topology, with emphasis on those aspects of the subject such as Continuity, Connectedness Compactness, Metrizabiliy, that are basic to higher mathematics.

CO3:To introduce the student to what it means to do mathematics, as opposed to learning about mathematics or to learning to do computational exercises.

CO4:To help the student learn how to write mathematical text according to the standards of the profession and inspiring them to study higher-level mathematics and to become a professional mathematician

Unit I Metric Spaces: General Properties: Examples of Metric Spaces – Open Sets, Closed Sets and Convergence Sequences – Continuous Mappings between Metric Spaces – Complete Metric Spaces – Compact Metric Spaces – Separable Metric Spaces.

Chapter 9: Sec 9.1 to 9.6 (Text Book 1)

Unit II Metric Spaces: Three Fundamental Theorems: The Arzelas-Ascoli Theorem – The Baire Category Theorem – The Banach Contraction Principle.

Chapter 10: Sec 10.1 to 10.3 (Text Book 1)

Unit III Topological Spaces and Continuous Function: Topological Spaces- Basics for a Topology – The Order Topology – The Product Topology on X ×Y – The Subspace Topology – Closed Sets and Limit Points – Continuous Functions – Product Topology – The Metric Topology.

Chapter 2: Sec 12 to 21 (Text Book 2)

Unit IV Connectedness and Compactness: Connected Spaces – Connected Subspaces of the Real Line –

Compact Spaces – Compact Subspaces of the Real Line.

Chapter 3: Sec 23, 24, 26, 27 (Text Book 2)

Unit V Countability and Separation Axioms: The Countability Axioms – The Separation Axioms – Normal Spaces – Te Urysohn Lemma – The Urysohn Metrization Theorem.

Chapter 4: Sec 30 to 34 (Text Book 2)

TEXT BOOK :

1. **Real Analysis** by H.L. Royden and P.M.Fitzpatrick. Fourth Edition. Pearson Education Asia Limited, 2010.
2. **Topology** by J.R. Munkers, Second Edition, Prentice Hall of India, New Delhi, 2004.

REFERENCE BOOKS :

1. J. Dugundji : Topology (Allyn and Bacon, Boston, 1966.)
2. 2. K. D. Joshi: Introduction to General Topology (Wiley Eastern Limited).
3. M. A. Armstrong, Basic Topology, Springer (India), 2004.

Evaluation Pattern – R.13 & R.16

Learning Outcomes

Requirement for teaching Profession. It is used in differentiable equations, dynamical systemsand Reimann surfaces in complex analysis. Used in string theory in physics. This components are useful :To introduce the concept of Metric spaces as a generalization of the analysis on the real line at a level and depth appropriate for introducing Topological spaces and for providing a prerequisite for the forth coming courses like Differential Geometry, Functional Analysis, Complex Analysis etc..To present an introduction to the field of topology, with emphasis on those aspects of the subject such as Continuity, Connectedness Compactness, Metrizabiliy, that are basic to higher mathematics.To introduce the student to what it means to do mathematics, as opposed to learning about mathematics or to learning to do computational exercises.To help the student learn how to write mathematical text according to the standards of the profession and inspiring them to study higher-level mathematics and to become a professional mathematician

15MAT504 Theory of Ordinary Differential Equations 4 0 0 4

Course Out Comes:

CO-1: Understand the existence - uniqueness conditions of solutions to first order equations and apply various methods to solve the initial value problems.

CO-2: Understand the concepts of the existence and uniqueness theorem, fundamental matrix, homogenous/nonhomogenous linear systems with constant coefficients and solve the problems involving central forces, planetary motion and some special equations.

CO-3: Understand the concepts of a complex n-dimensional space, the systems as vector equations, existence and uniqueness of solutions to systems.

CO-4: Understand the concepts of nonlinear equations, autonomous systems, the phase plane and its phenomena and stability for linear and nonlinear systems.

CO-5: Understand the concepts of periodic and oscillatory behaviors of a differential equation.

Existence-Uniqueness of Solutions to First Order Wquations: Equations with variable separated, Exact

equations, the method of successive approximations, Lipschitz condition, Convergence of successive approximations, Non–local existence of solutions, Approximations to and uniqueness of solutions.

Existence and Uniqueness of Solutions to Systems and n-th Order Equations: Introduction, An example – central forces and planetary motion, Some special equations, Complex n-dimensional space, Systems as vector equations, Existence and uniqueness of solutions to systems, Existence and Uniqueness of linear systems, Equations of order n.

Nonlinear equations: Autonomous Systems, The Phase plane and its phenomena, Types of critical points, Stability, critical points and stability, for linear systems, Stability by Liapunov's Direct method, Simple critical points of nonlinear systems, Nonlinear mechanics, Conservative systems, Periodic solutions, The Poincaré –Bendixson theorem.

Oscillations and the Sturm Separation theorem, The Sturm comparison theorem.

TEXTBOOK:

1. Differential equations with applications and historical notes, George F. Simmons and John S Robertson, Tata McGraw Hill Education Private Limited, 2003, Second Edition.
2. An introduction to ordinary differential equations, E.A. Coddington, PHI learning, 1999.

REFERENCES:

Ordinary differential equations and stability theory, S. G. Deo and V Raghavendra **Evaluation Policy**

Evaluation Pattern – R.13 & R.16

Learning Out Comes:

Requirement for teaching Profession. Used to solve and determine what function or functions satisfy the **equation**. for some arbitrary constant C. Understand the existence - uniqueness conditions of solutions to first order equations and apply various methods to solve the initial value problems.Understand the concepts of the existence and uniqueness theorem, fundamental matrix, homogenous/nonhomogenous linear systems with constant coefficients and solve the problems involving central forces, planetary motion and some special equations. Understand the concepts of a complex n-dimensional space, the systems as vector equations, existence and uniqueness of solutions to systems. Understand the concepts of nonlinear equations, autonomous systems, the phase plane and its phenomena and stability for linear and nonlinear systems. Understand the concepts of periodic and oscillatory behaviors of a differential equation.

Semester2

15MAT511 Advanced Complex Analysis 4-0-0-4

Course Out Comes:

CO1: Understand the concept of the Schwarz Reflection by complex conjugation, and its Applications

CO2:Understand the Riemann Mapping theorem

CO3:Understand the Analytic Continuation

CO4:To understand about the entire function and Meromorphic function

CO5:Understand about the Elliptic functions

Analytic Continuation: Direct Analytic Continuation, Monodromy Theorem, Poisson Integral Formula,

Analytic Continuation via Reflection.

Representations for Meromorphic and Entire Functions: Infinite Sums and Meromorphic functions, Infinite Product of Complex Numbers, Infinite Products of Analytic Functions, Factorization of Entire Functions, The Gamma Function, The Zeta Function Jensen's Formula, The Order and the Genus of Entire Functions.

Mapping Theorems: Open Mapping Theorem and Hurwitz' Theorem, Basic Results on Univalent Functions, Normal Families, The Riemann Mapping Theorem, Bieberbach Conjecture, The Bloch-Landau Theorems Picard's Theorem.

TEXT BOOK

1. L. Ahlfors, *Complex Analysis, 2nd Ed.*, McGraw-Hill,New York, 1966.

REFERENCES

1. T.W. Gamelin, *Complex Analysis*, Springer-Verlag, 2001
2. S. Ponnusamy and H. Silverman, *Complex Variables with Applications*, Springer, 2006.

R. Roopkumar, Complex Analysis, Pearson Education, 2014, Chennai. **Evaluation Policy**

Evaluation Pattern – R.13 & R.16

Learning Out Comes:

Requirement for teaching Profession. **Complex analysis** also has applications in engineering fields such as nuclear, aerospace, mechanical and electrical engineering This components are useful to Understand the concept of the Schwarz Reflection by complex conjugation, and its ApplicationsUnderstand the Riemann Mapping theorem.Understand the Analytic Continuation.:To understand about the entire function and Meromorphic function.Understand about the Elliptic functions

15MAT514 Theory of Partial Differential Equations 3-1-0-4

Course Out Comes:

CO-1: Understand the existence - uniqueness conditions of solutions to first order equations and apply various methods to solve the initial value problems.

CO-2: Understand the concepts of the existence and uniqueness theorem, fundamental matrix, homogenous/nonhomogenous linear systems with constant coefficients and solve the problems involving central forces, planetary motion and some special equations.

CO-3: Understand the concepts of a complex n-dimensional space, the systems as vector equations, existence and uniqueness of solutions to systems.

CO-4: Understand the concepts of nonlinear equations, autonomous systems, the phase plane and its phenomena and stability for linear and nonlinear systems.

CO-5: Understand the concepts of periodic and oscillatory behaviours of a differential Equations

First order PDE - Geometrical Interpretation of a First-Order Equation, Method of Characteristics and General Solutions, Canonical Forms of First-Order Linear Equations

Second-Order Linear Equations - Second-Order Equations in Two Independent Variables, Canonical

Forms, Equations with Constant Coefficients

Cauchy Problem and Wave Equations - The Cauchy Problem, The Cauchy-Kowalewskaya Theorem, Homogeneous Wave Equations, Initial Boundary-Value Problems, Equations with Nonhomogeneous Boundary Conditions, Vibration of Finite String with Fixed Ends,(review) Nonhomogeneous Wave Equations.

Boundary-Value Problems - Boundary-Value Problems, Maximum and Minimum Principles, Uniqueness and Continuity Theorems, Dirichlet Problem for a Circle, Dirichlet Problem for a Circular Annulus, Neumann Problem for a Circle, Dirichlet Problem for a Rectangle , Dirichlet Problem Involving the Poisson Equation, The Neumann Problem for a Rectangle

TEXTBOOK:

1. Tyn Myint-U, Lokenath Debnath Linear Partial Differential Equations for Scientists and Engineers, Birkhauser, Boston, Fourth Edition, 2007.

REFERENCES:

1. L.C. Evans, Partial Differrential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, Providence, 1998.

I.N. Sneddon, Elements of partial differential equations, McGraw Hill, New York, 1986.

Evaluation Pattern – R.13 & R.16

Learning Out Comes:

Requirement for teaching Profession. **Complex analysis** also has applications in engineering fields such as nuclear, aerospace, mechanical and electrical engineering This components are useful to Understand the concept of the Schwarz Reflection by complex conjugation, and its ApplicationsUnderstand the Riemann Mapping theorem.Understand the Analytic Continuation.:To understand about the entire function and Meromorphic function.Understand about the Elliptic functions

15MAT512 Functional Analysis 4-0-0-4

Course Out Comes:

CO1: To understand the concepts of linear space, metric space and normed linear space. To analyze the spaces which has both linear structure and metric structure. To apply this new structure on set of all transformations and operators, so that continuity and boundedness becomes equivalent. By applying these results, we obtain a new normed spaces of all bounded linear transformations.

CO2: To understand and review the concepts from real analysis such as Integration and Differentiation, Compact Spaces and separability of compact metric Spaces. To apply and evaluate the corresponding results in this normed spaces.

CO3: To understand finite dimensional normed spaces and operators on it. To understand and apply Stone Weierstrass Theorem, Ascoli-Arzela Theorem and Peano's Theorem.

CO4: To understand dual spaces and reflexive spaces. To understand and apply Hahn Banach Theorem.

CO5: To understand convex sets. To understand and apply The Riesz Representation Theorem and Hergoltz's Theorem.

Unit – I : **Normed Linear Spaces :** Linear Spaces – Normed Linear Spaces – The Metric on a Normed Linear Space – Linear Subspaces – Bounded Linear Transformations.

Sections : 3.1 to 3.5 (Text Book – 1)

Unit – II : **Linear Homeomorphisms** – An Elementary Integral – Regulated Mappings – Integration and Differentiation - Review of Compact Metric Spaces – Basic Results on Compact Subsets of a Metric Space – Separability of Compact Metric Spaces – Conditions Equivalent to Compactness - Borel – Lebesgue Theorem

Sections: 3.7 to 3.9 and 4.1 to 4.2 (Text Book – 1)

Unit – III : - Compactness and Continuity – Dini's Theorem- Finite Dimensional Normed Linear Spaces – Completeness – Stone Weierstrass Theorem – Weierstrass Theorem on approximation of periodic functions by trigonometric polynomials – Extension of Stone-Weirstrass Theorem to $C_c(X)C_c(X)$ - Separability of $C_K(X)C_K(X)$ - Ascoli-Arzela Theorem – Peano's Theorem

Sections: 4.3 to 4.6 (Text Book – 1)

Unit – IV: **Bounded Linear Functionals** – Some Dual Spaces – The Hahn-Banach Theorem – The Existence of Bounded Linear Functionals – Reflexivity of the Banach Space $l^p l^p$ - Annihilators.

Sections: 5.1 to 5.4 (Text Book – 1)

Unit V: A Theorem on Convex Sets – The Riesz Representation Theorem – Hergoltz's Theorem

Sections 5.5 to 5.7 (Text Book – 1)

Text Books:

1. Elements of Functional Analysis by A.L. Brown and A. Page, Van Norstrand Reinhold Company, London, 1970.
2. Functional Analysis by Balmohan V Limaye, New Age International Publishers, Third Edition, Reprint 2014.

Evaluation Pattern – R.13 & R.16

Learning Out Comes:

Requirement for teaching Profession. It has applications in problems related to ordinary and partial differential equations, numerical analysis, calculus of variations, approximation theory, integral equations, and so on. These components are useful to understand the concepts of linear space, metric space and normed linear space. To analyze the spaces which has both linear structure and metric structure. To apply this new structure on set of all transformations and operators, so that continuity and boundedness becomes equivalent. By applying these results, we obtain a new normed spaces of all bounded linear transformations. To understand and review the concepts from real analysis such as Integration and Differentiation, Compact Spaces and separability of compact metric Spaces. To apply and evaluate the corresponding results in this normed spaces. To understand finite dimensional normed spaces and operators on it. To understand and

apply Stone Weierstrass Theorem, Ascoli-Arzela Theorem and Peano's Theorem. To understand dual spaces and reflexive spaces. To understand and apply Hahn Banach Theorem.To understand convex sets. To understand and apply The Riesz Representation Theorem and Hergoltz's Theorem.

15MAT513 Graph Theory 4 0 0 4

Course Out Comes:

CO-1: Understand the basic concepts of graphs and trees.
CO-2: Understand and apply the concepts of graph connectivity and shortest path problems.
CO-3: Understand and apply the concepts of matching problems in job assignments.
CO-4: Understand the concepts of vertex and edge colorings.
CO-5: Understand the concepts of planar graphs and dual graphs.

Review of Graphs: Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm.

Trees: Trees, cut-edges and cut-vertices, spanning trees, minimum spanning trees, DFS, BFS algorithms.

Connectivity: Graph connectivity, k-connected graphs and blocks.

Euler and Hamilton Graphs: Euler graphs, Euler's theorem. Fleury's algorithm for Eulerian trails. Necessary / sufficient conditions for the existence of Hamilton cycles, Chinese-postman-problem, approximate solutions of traveling salesman problem

Matching: Matchings, maximal matchings. Coverings and minimal coverings. Berge's theorem, Hall's theorem, Tutte's perfect matching theorem, Job assignment problem.

Coverings, Independent Sets and Cliques; Basic Relations.

Colorings: Vertex colorings, greedy algorithm and its consequences, Brooks' theorem. Edge-colorings, Vizing theorem on edge-colorings.

Planar graphs: Euler formula. Dual graphs. Kuratowaski's Characterization, Planarity testing algorithm.

TEXT BOOKS

1. J.A. Bondy and U.S.R. Murty, *Graph Theory and Applications*, Springer, 2008.

REFERENCES BOOKS

1. D.B. West, *Introduction to Graph Theory*, P.H.I. 2010.
2. Frank Harary, Graph Theory, New York Academy of Sciences, 1979.
3. Russel Merris, Graph Theory, John Wiley, 2011.

Evaluation Pattern – R.13 & R.16

Learning Out Comes :

Requirement for teaching Profession. Graph theoretical concepts are widely used to study and model various applications, in different areas. They include, study of molecules, construction of bonds in chemistry and the study of atoms. And in sociology to measure actors prestige or to explore diffusion mechanisms.:

Understand the basic concepts of graphs and trees. Understand and apply the concepts of graph connectivity and shortest path problems. Understand and apply the concepts of matching problems in job assignments. Understand the concepts of vertex and edge colorings. Understand the concepts of planar graphs and dual graphs

Elective **3 0 0 3**

Semester3

15MAT604 Operator Theory **4 0 0 4**

Course Out Comes:

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CO1: To understand compact operators and apply in Fredholm Theory and C - algebras.

CO2: To understand and apply Gelfand-Neumark representation theorem.

CO3: To understand and apply projections, Toeplitz operators. *

Compact operators on Hilbert Spaces. (a) Fredholm Theory (b) Index, C - algebras - noncommutative states and representations, Gelfand-Neumark representation theorem, Von-Neumann algebras; projections, double commutant theorem, L functional calculus, Toeplitz operators.

Unit I : Bounded Linear Operators – Examples – The Algebra of Bounded Linear Operators – The Spectrum of a Bounded Linear Operator – The Adjoint of a Bounded Linear Transformation.

Sections : 6.1 to 6.4 (Text Book – 1)

Unit II: Compact Linear Operators – The Riesz-Schauder Theory of Compact Linear Operators – The Spectrum of a Compact linear Operator – Fredholm Integral Equations

Sections : 6.5 to 6.8 (Text Book – 1)

Unit III: Baire's Theorem – Nowhere Differentiable Continuous Functions – Pointwise Limits of Continuous Functions – The Principle of Uniform Boundedness – The Open Mapping Theorem – The Closes Graph Theorem

Sections : 8.1 to 8.5 and 8.8 (Text Book – 1)

Unit IV: Spectral Theory in Hilbert Spaces: Hermitian Symmetric Forms – Orthogonality – The Hilbert Space Adjoint – Self-adoint Bounded Linear Operators

Sections : 9.1 to 9.4 (Text Book – 1)

Unit V: (Spectral Theory in Hilbert Spaces continued): Self-adjoint Compact Linear Operators – Positive Linear Operators - Orthogonal Projections – Functions of Self-adjoint Bounded Linear Operators – The Spectral Theorem.

Sections : 9.5 to 9.9

Text Book:

1. Elements of Functional Analysis by A.L. Brown and A. Page, Van Norstrand Reinhold Company, London, 1970.

2. Introduction to Functional Analysis with Applications by A.H. Siddiqi, Khalil Ahmad and P. Manchanda. Anamaya Publishers New Delhi 2007.
3. Functional Analysis by Balmohan V Limaye, New Age International Publishers, Third Edition, Reprint 2014.

Evaluation Pattern – R.13 & R.16

Learning outcomes:
Requirement for teaching Profession. To analyze problems arising from concrete classes of integral, differential and difference equations. These components are useful to understand compact operators and apply in Fredholm Theory and C^* - algebras. To understand and apply Gelfand-Neumark representation theorem.: To understand and apply projections, Toeplitz operators.Compact operators on Hilbert Spaces. (a) Fredholm Theory (b) Index, C^* - algebras - noncommutative states and representations, Gelfand-Neumark representation theorem, Von-Neumann algebras; projections, double commutant theorem, L^∞ functional calculus, Toeplitz operators.

15MAT602 Fluid Dynamics 4 0 0 4

Course Out Comes:

CO- 01: To understand the Lagrangian and Eulerian frames of references, to apply mass conservation to derive Equation of Continuity and to familiarize basic ideas in fluid motion.
CO-02: To apply principles of momentum conservation and energy conservation to derive Equation of Motion and Equation of Energy.
CO-03 : To understand two dimensional fluid flow and to understand Milne-thomson Circle Theorem and Blasius Theorem.
CO - 04: To understand general theory of irrotational theorem and Kelvin's theorem on permancence of irrotation motion.
CO-05: To apply the equations of motion to to find closed form solutions of simple flow problems and to understand the limitations of the theory through simple paradoxes.

Basic Concepts and Properties

Fluid – definition, distinction between solid and fluid - Units and dimensions – Properties of fluids – density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillary and surface tension – Fluid statics: concept of fluid static pressure, absolute and gauge pressures – pressure measurements by manometers and pressure gauges.

Fliud Kinematics and Fluid Dynamics

Fluid Kinematics - Flow visualization - lines of flow - types of flow - velocity field and acceleration - continuity equation (one and three dimensional differential forms)- Equation of streamline - stream function - velocity potential function - circulation - flow net – fluid dynamics - equations of motion - Euler's equation along a streamline - Bernoulli's equation – applications - Venturi meter, Orifice meter, Pitot tube - dimensional analysis - Buckingham's ? theorem- applications - similarity laws and models.
Incompressible Fluid Flow

Viscous flow - Navier - Stoke's equation (Statement only) - Shear stress, pressure gradient relationship -

laminar flow between parallel plates - Laminar flow through circular tubes (Hagen poiseulle's) - Hydraulic and energy gradient - flow through pipes - Darcy -weisback's equation - pipe roughness -friction factor- Moody's diagram-minor losses - flow through pipes in series and in parallel - power transmission - Boundary layer flows, boundary layer thickness, boundary layer separation - drag and lift coefficients.

TEXT BOOKS

1. Streeter, V.L., and Wylie, E.B., *Fluid Mechanics*, McGraw-Hill, 1983.
2. Kumar, K.L., *Engineering Fluid Mechanics*, Eurasia Publishing House (P) Ltd., New Delhi (7^{th} Edition), 1995.

REFERENCES

1. White, F.M., *Fluid Mechanics*, Tata McGraw-Hill, 5^{th} Edition, New Delhi, 2003.

Evaluation Pattern – R.13 & R.16

15MAT601 Advanced Topology 4 0 0 4

Course Out Comes:

CO-1: To understand the basic definition of continuity in topological space and its properties through examples. To study the rules for constructing continuous functions and topological spaces. To understand the relationship between two topological spaces.

CO-2: To understand the concepts of connected spaces, separation, path connectedness and locally connected through examples.

CO-3: To study the basic properties of compact spaces. To understand the concepts of limit point compactness, sequentially compact, local compactness, compactification, one point compactification through examples.

CO-4: To understand countability axioms , separation axioms and its properties.

CO-5: To understand the behaviour of compactness in product topology and properties of completeness through Tychonoff's theorem and Baire category theorem respectively**.**

Countability and Separation Axioms: Urysohn lemma, Metrization theorem and Tietze extension theorem. Tychonoff theorem. Stone-Cech campactification.

Metrization and Paracompactness: Local finiteness. Nagata-Smirnov Metrization theorem. Paracompactness. Smirnov Metrization theorem.

Complete metric spaces. Compactness in metric spaces. Pointwise and compact convergence. And Ascoli's theorem.

Baire spaces. Introduction to dimension theory.

Introduction to Fundamental group: Homotopy of paths. Fundamental group. Covering spaces. Fundamental group of cycle. Retractions and fixed points.

TEXT BOOK : J.R. Munkers : Topology A first Course , Prentice Hall of India.

REFERENCE BOOKS :

1. Dugundji : Topology (Allyn and Bacon, Boston, 1966.)

2. K. D. Joshi : Introduction to General Topology (Wiley Eastern Limited

3 M. A. Armstrong, Basic Topology, Springer (India), 2004.

Evaluation Pattern – R.13 & R.16

Learning Out Comes:

Requirement for teaching Profession. It is used in string theory in physics, and for describing the space-time structure of universe. These components are useful to understand the basic definition of continuity in topological space and its properties through examples. To study the rules for constructing continuous functions and topological spaces. To understand the relationship between two topological spaces. To understand the concepts of connected spaces, separation, path connectedness and locally connected through examples. To study the basic properties of compact spaces. To understand the concepts of limit point compactness, sequentially compact, local compactness, compactification, one point compactification through examples.To understand countability axioms , separation axioms and its properties. To understand the behaviour of compactness in product topology and properties of completeness through Tychonoff's theorem and Baire category theorem respectively**.**

. **15MAT603 Measure and Integration 4 0 0 4**

Course Outcomes:

CO -01: To understand the notion of measure of a set on the real line and the measurable sets and functions
CO-02: To understand the notion of Lebesgue Integrals as a generalization of Riemann Integrals
CO-03: To understand abstract measure spaces and integration with respect to a measure
CO-04: To understand and apply various inequalities to establish the completeness of
CO-05: To understand Raydon-Nikodym Theorem its Applications

Unit I Measure on the Real Line: Lebesgue Outer Measure - Measurable Sets – Regularity -Measurable Functions - Borel and Lebesgue Measurability.(sections 2.1 to 2.5)

Unit II Integration of Functions of a Real Variable: Integration of Non-Negative Functions - The General Integral - Integration of Series - Riemann and Lebesgue Integrals.(sections 3.1 to 3.4)

Unit III Abstract Measure Spaces: Measures and Outer Measures - Extension of a Measure -Uniqueness of the Extension - Completion of a Measure - Measure Spaces - Integration with Respect to a Measure (sections 5.1 to 5.6).

Unit IV Inequalities and the L^p Spaces: The L^p Spaces - Convex Functions - Jensen's Inequality - The Inequalities of Holder and Minkowski - Completeness of $L^p(\mu)$.(sections 6.1 to 6.5)

Unit V Signed Measures and their Derivatives: Signed Measures and the Decomposition - The Jordan Decomposition - The Radon-Nikodym Theorem - Some Applications of the Radon-Nikodym Theorem (sections 8.1 to 8.4)

Text Book:

Measure Theory and Integration by **G.de Barra.** First Edition. New Age International Publishers, Reprint 2000.

Reference Book:

Real Analysis by H.L. Royden and P.M.Fitzpatrick. Fourth Edition. Pearson Education Asia Limited, 2010. 3 M. A. Armstrong, Basic Topology, Springer (India), 2004.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

Requirement for teaching Profession. Topology is used in many branches of mathematics, such as differentiable equations, dynamical systems, knot theory, and Riemann surfaces in complex analysis.these components are useful to understand the notion of measure of a set on the real line and the measurable sets and functions. To understand the notion of Lebesgue Integrals as a generalization of Riemann Integrals. To understand abstract measure spaces and integration with respect to a measure. To understand and apply various inequalities to establish the completeness. To under.stand Raydon-Nikodym Theorem its Applications.

15MAT605 – Differential Geometry (4-0-0-4)

CO1:The student will be able to compute quantities of geometric interest such as curvature, as well as develop a facility to compute in various specialized systems, such as semigeodesic coordinates or. ones representing asymptotic lines or principal curvatures

CO2 :. The student will also be introduced to the method of the moving frame and overdetermined systems of differential equations as they arise in surface theory.

CO3: Students will start being able to develop arguments in the geometric description of curves and surfaces in order to establish basic properties of geodesics, parallel transport, evolutes, minimal surfaces.

Course Overview

Differential Geometry is a course offered to 9th semester Integrated MSc (Physics and Mathematics) and 3rd semester MSc Mathematics students. Students taking this course should have completed a basic course on advanced calculus and analytic geometry as a prerequisite. The course itself is mathematically rigorous, but still emphasizes concrete aspects of geometry, centred on the notion of curvature. Curvature and its related aspects are defined on curves and surfaces in three dimensions. These primary concepts forms the core of this course. Differential geometry finds a wide variety of applications in modern day research with data embedding and big data being the most relevant.

Course Syllabus

Unit-I

Curves in the plane and in space, arc-length, re-parametrization, level curves Vs parametrized curves.

Unit-II

Curvature, plane curves, space curve-global properties of curves, the isoperimetric inequality, and the four vertex theorem.

Unit-III

Surfaces in the three dimension, smooth surfaces, tangents, normal and orientability, quadratic surfaces, triply orthogonal systems, applications of inverse function theorem, the first fundamental form, lengths of curves on surfaces, isometric surfaces.

Unit-IV

Conformal mapping of surfaces, surfaces area, equiareal maps and a theorem of Archimedes, curvature of surfaces, the second fundamental form, the curvature of curves on a surface, the normal and principal curvatures, geometric interpretation of principal curvatures.

Unit-V

The Gaussian curvature and the mean curvatures, the pseudoshere, flat surfaces, surfaces of a constant mean curvature, Gaussian curvature of a compact surfaces, the Gauss map.

Text Book:

1. Andrew Pressley, Elementary Differential Geometry, Springer, 2006.

Reference Books:

1. Thierry Aubin, A Course in Differential Geometry, American Mathematical Society, 2007.
2. K. L. Wardle, Differential Geometry, Dover, 2008.

Evaluation Pattern – R.13 & R.16

Learning Outcomes

Requirement for Teaching Profession. In structural geology, differential geometry is used to analyze and describe geologic structures. In computer vision, differential geometry is used to analyze shapes. In image processing, differential geometry is used to process and analyse data on non-flat surfaces.. This components are useful to understand parametrisations and the elementary notion of curvature on curves and surfaces. Study and analyse techniques and results on smooth curves and surfaces in space. Identify and enumerate some standard examples and properties related to curves and surfaces Study the applications related to the first and second fundamental forms. Articulate connections between geometry and other disciplines, possibly including topology, algebra, analysis, or applied mathematics

Elective **3 0 0 3**

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Semester X

Two Electives

Project: 18MAT696 **Project/Dssertation** **10 cr**

Course Out Comes:
: Identify and understand some open problems for the dissertation /project

Elective **3 0 0 3**

Elective **3 0 0 3**

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Elective Courses

15MAT631 ALGEBRAIC GEOMETRY **3 0 0 3**

Course Out Comes:

CO 1: To understand the various structures introduced in Algebraic geometry and to prove the standard theorems due to Hilbert/Krull/Noether which give correspondence between algebraic varieties and ideals, rings and fields.
CO 2: To understands properties of morphisms and its applications
CO 3: To familiarize the concept of rational maps
CO 4: To identify non singualrity through various criteria and understand the process of desingularisation
CO 5: To familiarize the idea of multiplicity and intersection with examples

Unit 1 AFFINE AND PROJECTIVE VARIETIES

Noetherian rings and modules; Emmy Noether's theorem and Hilbert's Basissatz; Hilbert's Nullstellensatz; Affine and Projective algebraic sets; Krull's Hauptidealsatz; topological irreducibility, Noetherian decomposition; local ring, function field, transcendence degree and dimension theory; Quasi-Compactness and Hausdorffness; Prime and maximal spectra; Example: linear varieties, hypersurfaces, curves.

Unit 2 MORPHISMS

Morphisms in the category of commutative algebras over a commutative ring; behaviour under localization; morphisms of local rings; tensor products; Product varieties; standard embeddings like the segre- and the d-uple embedding.

Unit 3 RATIONAL MAPS

Relevance to function fields and birational classification; Example: Classification of curves; blowing-up.

Unit 4 NONSINGULAR VARIETIES

Nonsingularity; Jacobian Criterion; singular locus; Regular local rings; Normal rings; normal varieties; Normalization; concept of desingularisation and its relevance to Classification Problems; Jacobian Conjecture; relationships between a ring and its completion; nonsingular curves.

Unit 5 INTERSECTIONS IN PROJECTIVE SPACE

Notions of multiplicity and intersection with examples.

TEXTBOOKS / REFERENCES BOOKS

1. Robin Hartshorne, Algebraic Geometry, Graduate Texts in Mathematics (GTM) 8th Printing, Springer, 1997.

2. C. Musili, Algebraic Geometry for Beginners, Texts and Readings in Mathematics 20, Hindustan Book Agency, 2001.

Evaluation Pattern – R.13 & R.16

15MAT632 ALGEBRAIC TOPOLOGY 3 0 0 3

Course Out Comes:

CO 1: To understand the concept complexes define homology groups

CO 2: To obtain homology groups for various pseudo manifolds

CO 3: To prove Brouwer fixed point theorem and understand its uses

CO 4: To familiarise the concept of homotopy theory and its role in topological spaces

Co 5: To find out the fundamental groups of various spaces and anayse the topological structures.

Unit 1

Geometric Complexes and Polyhedra: Introduction. Examples. Geometric Complexes and Polyhedra; Orientation of geometric complexes.

Simplicial Homology Groups: Chains, cycles, Boundaries and homology groups, Examples of homology groups; The structure of homology groups.

Unit 2

The Euler Poincare's Theorem; Pseudomanifolds and the homology groups of Sn. [Chapter 1 Sections 1.1 to 1.4 & Chapter 2 Sections 2.1 to 2.5 from the text].

Unit 3

Simplicial Approximation: Introduction; Simplicial approximation; Induced homomorphisms on the Homology groups; The Brouwer fixed point theorem and related results;

Unit 4

The Fundamental Group: Introduction; Homotopic Paths and the Fundamental Group; The Covering Homotopy Property for S1;

[Chapter 3 Sectins 3.1 to 3.4; Chapter 4 Sections 4.1 to 4.3]

Unit 5

Examples of Fundamental Groups; The Relation Between H1(K) and p1(iKi); Covering Spaces: The definition and some examples. Basic properties of covering spaces. Classification of covering spaces. Universal covering spaces. Applications.

[Chapter 4: Sections 4.4, 4.5; Chapter 5 Sections 5.1 to 5.5 from the text]

TEXT BOOK

Fred H. Croom: Basic Concepts of Algebraic Topology, UTM, Springer, NY, 1978.

REFERENCES BOOKS:

1. Eilenberg S and Steenrod N: Foundations of Algebraic Topology, Princetion Univ. Press, 1952.

2. S.T. Hu: Homology Theory, Holden-Day, 1965.

3. S.T. Hu: Homology Theory, Academic Press, 1959.

Evaluation Pattern – R.13 & R.16

15MAT633 CODING THEORY 3 0 0 3

Course Out Comes:

CO-1: To understand the basic concepts of linear/error correcting codes and apply the concepts to encode and decode the information.

CO-2: To understand the concepts of dual /Hamming codes and apply the concept to find the parameters of given codes and their dual codes using standard matrix and polynomial operations .

CO-3: To familiarize the concepts of cyclic/BCH codes with required properties.

CO-4: To understand the concepts of weight enumerators and apply to find the weight information of the code.

To familiarize the concept of MDS code.

CO-5: Apply the basic concepts of linear codes to solve problems .

Unit 1 Introduction to linear codes and error correcting codes. Encoding and decoding of a linear code,

Unit 2 Dual codes. Hamming codes and perfect codes.

Unit 3 Cyclic codes. Codes with Latin Squares, Introduction to BCH codes.

Unit 4 Weight ennumerators and MDS codes.

Unit 5 Linear coding theory problems and conclusions.

TEXT BOOKS:

- *Raymond Hill, A first course in Coding Theory, Clarandon Press, Oxford (1986).*
- *J.H. Van Lint, Introduction to Coding Theory, Springer (1998).*

REFERENCES

1. W. Cary Huffman and Versa Pless, Fundamentals of Error Correcting Codes, Cambridge University Press (2003).

2. W.W. Peterson, Error Correcting Codes, Cambridge, MA MIT Press (1961).

3. V. Pless, W.C. Huffman and R.A. Brualdi, An Introduction to Algebraic Codes, in Hand book of coding theory, Eds. Amsterdam Elsevier (1998).

Evaluation Pattern – R.13 & R.16

15MAT634 COMMUTATIVE ALGEBRA 3 0 0 3

Course Outcomes:

CO-1: To understand the basic definitions of rings, ideals and modules through examples; To construct new modules by tensor product, Hom, direct sum/product.

CO-2: To understand the fractions of modules and apply the fractions to construct the field from integral domain. To familiarize the decomposition of rings/modules.

CO-3: To familiarize the concept of integral dependence of extension ring and chain conditions of modules. To understand the definitions of valuations / Noetherian / Artin rings through examples.

CO-4: To study the basic properties of Noetherian/Artin rings; use the basic properties to characterize/decompose the Noetherian/Artin rings.

CO-5: To understand the basic definitions of discrete valuation rings and Dedekind domains. To familiarize the concept of dimension theory of rings/modules.

Unit 1 Rings and ideals, modules and operations on them (tensor product, Hom, direct sum and product).

Unit 2 Rings and modules of Fractions, primary decomposition.

Unit 3 Integral dependence and Valuations, Chain Conditions.

Unit 4 Noetherian Rings and Artin Rings.

Unit 5 Discrete valuation Rings and Dedekind Domains, Dimension theory.

TEXT BOOKS / REFERENCES

1. Atiyah-Macdonald, Commutative Algebra, Westview Press, 1994.

2. Zariski and Samuel, Commutative Algebra I, II , Springer, 1991.

3. Eisenbud, Commutative Algebra with a View Towards Algebraic Geometry, Springer, 1995.

4. Bourbaki, Commutative Algebra, Springer, 1989.

Evaluation Pattern – R.13 & R.16

15MAT635 LIE ALGEBRA 3 0 0 3

Course Outcome:

CO 1: To understand the concept of Lie algebra and to know the substructures and operations on them.

CO 2: To familiarize nilpotent and solvable Lie algebras and prove the Engel's theorem

CO 3: To understand theorems on Semi simple Lie algebras and their applications .

CO 4: To derive various decomposition theorems on Lie algebras

Co 5: To understand the classification of Lie algebras through Dynkin diagrams.

Unit 1 Basic Concepts - Definition and Examples, Lie Algebra of Derivations, Adjoint Representation, Structure Constants, Direct Sums, Homomorphism and Isomorphisms, Ideals, Centre and Derived Algebra of a Lie Algebra, Simple Lie Algebras, The Normalizer of a Subalgebra and Centralizer of a Subset in Lie Algebras, Automorphism and Inner Automorphism of a Lie Algebra. (Book 1, Chapters 1 and 2).

Unit 2 Descending Central Series of a Lie Algebra, Nilpotent Lie Algebras. Derived Series of a Lie Algebra, Radical of a Lie Algebra, Solvable Lie Algebras, Engel's Theorem. (Book 1, Chapter 3).

Unit 3 Semisimple Lie Algebras - Theorems of Lie and Cartan, Jordan-Chevalley Decomposition, Cartan's Criterion. (Book 1, Chapter 4)

Unit 4 Killing Form, Inner Derivations, Abstract Jordan Decomposition, Complete Reducibility of Lie algebras. (Book 1, Chapter 5)

Unit 5 The Weyl Group, Root Systems. (Book 1, Chapter 10)

TEXT BOOKS / REFERENCES BOOKS

1. Jacobson, Lie Algebras, Dover, 1979.
2. J.P. Serre, Lie Algebras and Lie Groups, Benjamin, 1965 (Translated from French).
3. J.E. Humphreys, Introduction to Lie Algebras and Representation Theory, Springer-Verlag, 1980.

Evaluation Pattern – R.13 & R.16

15MAT636 THEORY OF MANIFOLDS 3 0 0 3

Course Out Comes:

CO 1: To familiarize the concept of manifolds and learn their properties
CO 2: To understand the concept of tangent spaces and its properties
CO 3: To generalize the ideas of curves/derivatives to manifolds
CO 4: To prove the inverse /implicit function theorems in manifolds

Co 5: To understand Riemannian manifolds and their relevance

Unit 1
Definition of Manifolds, Differentiable and Analytic Manifolds, Examples of Manifolds, Product of Manifolds, Mappings between Manifolds, Submanifolds, Tangent Vectors.

Unit 2
Differentials, The Differential of a Function, Infinitesimal Transformation, Tangent Space, Tangent Vector.

Unit 3
Cotangent Space, Vector Fields, Smooth Curve in a Manifold. Differential Forms k-forms, Exterior Differential, its Existence and Uniqueness.

Unit 4
Exact Differential Forms. De Rham Cohomology Group, Betti Number, Poincare's Lemma, Inverse Function Theorem, Implicit Function Theorem and its Applications, Integral Curve of a Smooth Vector Field.

Unit 5
Orientable Manifolds Definition and Examples. Smooth Partition of Unity Definition and Existence. Riemannian Manifolds Definition and Examples.

TEXTBOOKS / REFERENCES:

- *P.M.Cohn, "Lie Groups", Cambridge University Press, 1965.*
- *Claude Chevalley, "Theory of Lie Groups", Fifteenth Reprint, Princeton University Press, 1999.*

Evaluation Pattern – R.13 & R.16

15MAT637 Linear Algebra and its Applications 3 0 0 3

Course Outcomes:

CO-1: To understand inner products and compute the angle/length of a vector. To apply Gram-Schmidt process to construct the orthonormal basis.

CO-2: To familiarize the concept of characteristic roots/ vectors and related properties. To apply the link between linear transformation and matrix to find characteristic roots/ vectors.

CO-3: To understand the construction of matrices for a linear transformation in the triangular/Jordan form. To apply the canonical form to find the rank of the matrix/transformation.

CO-4: To familiarize the types of matrices, understand their properties and apply them in transformation.

CO-5: To understand the process of diagonalizing and apply diagonalization to identify Conic Sections.

Unit 1 Review: Vector Spaces.

Inner Products, Angle and Orthogonality in Inner Product Spaces, Length of a Vector, Schwarz Inequality, Orthogonal Vectors, Orthogonal Complement, Orthogonal Bases: Gram-Schmidt Process. **(Sec. 4.4)**

Unit 2 The Algebra of Linear Transformations, Characteristic Roots, Invertible Linear transformations, Characteristic Roots, Characteristic Vector, Minimal Polynomial, Matrices, Matrix of a Linear Transformation. **(Sec. 6.1 to 6.3).**

Unit 3 Canonical Forms: Triangular, Nilpotent Transformations, Jordan and Rational Canonical Form, invariant subspaces, cyclic subspaces.
(Sec. 6.4 to 6.6).

Unit 4 Trace and Transpose, Determinants, Symmetric and Skew Symmetric Matrices, Adjoint and Hermitian Adjoint of a Matrix, Hermitian, Unitary and Normal Transformations, Self Adjoint and Normal Transformations. **(Sec. 6.8 to 6.10)**

Unit 5 Problems in Eigen Values and Eigen Vectors, Diagonalization, Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms, Conic Sections. **(Sec. 7.1 to 7.3 and 9.5 to 9.6 from Reference Book 2)**

TEXT BOOK:

1. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

REFERENCES:

1. David C. Lay, Linear Algebra and its Applications, Pearson.
2. Gilbert Strang,' Linear Algebra and its Applications, Fourth Edition, Cengage Learning, 2014.
3. Howard Anton and Chris Rorres, 'Elementary Linear Algebra', 9th Edition, Wiley, 2005.
4. Nabil Nassif, Jocelyne Erhel, Bernard Philippe, Introduction to Computational Linear Algebra, CRC press, 2015.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

Requirement for Teaching Profession. Linear algebra is used in most sciences and engineering areas, because it allows modeling many natural phenomena, and efficiently computing with such models. To understand inner products and compute the angle/length of a vector. To apply Gram-Schmidt process to construct the orthonormal basis. To familiarize the concept of characteristic roots/ vectors and related properties. To apply the link between linear transformation and matrix to find characteristic roots/ vectors. To understand the construction of matrices for a linear transformation in the triangular/Jordan form. To apply the canonical form to find the rank of the matrix/transformation. To familiarize the types of matrices, understand their properties and apply them in transformation. To understand the process of diagonalizing and apply diagonalization to identify Conic Sections.

15MAT641 FIXED POINT THEORY 3 0 0 3

Course Outcomes:

CO-1: Understand and apply the concepts of fixed point theorems to prove the existence and uniqueness of solution to certain ordinary differential equations.

CO-2: To understand the existence and uniqueness of fixed point for non expansive and set valued mappings.

CO-3: To understand the existence of best approximation point for non expansive mapping and its applications.

CO-4: To understand the existence and uniqueness of fixed point for partially ordered metric space.

As an application, to prove the existence and uniqueness of solution for a periodic boundary value problem.

CO-5: Applying the fixed point theorems of multivalued mappings to demonstrate the conditions for existence of Nash equilibria in strategic games.

Unit 1 Contraction Principle, and its variants and applications;

Unit 2 Fixed points of non-expansive maps and set valued maps, Brouwer-Schauder fixed point theorems,

Unit 3 Ky Fan Best Approximation Theorem, Principle and Applications of KKM - maps, their variants and applications.

Unit 4 Fixed Point Theorems in partially ordered spaces and other abstract spaces.

Unit 5 Application of fixed point theory to Game theory and Mathematical Economics.

TEXTBOOKS / REFERENCES BOOKS

- *M.A. Khamsi and W.A. Kirk, An Introduction to Metric Spaces and Fixed Point Theory, Wiley - Inter Sci. (2001).*
- *Sankatha Singh, Bruce Watson and Pramila Srivastava, Fixed Point Theory and Best Approximation: The KKM - map Principle, Kluwer Academic Publishers, 1997.*
- *Kim C. Border, Fixed Point Theorems with Applications to Economics and Game Theory, Cambridge University Press, 1985.*

Evaluation Pattern – R.13 & R.16

15MAT642 FRACTALS 3 0 0 3

Course Outcomes:

- Understand the basic concepts and structure of fractals .
- Understand the space of fractals and transformation on metric spaces.

- Understand the iterated function system with contraction mapping theorem.
- Apply fractal concepts to compute fractal dimension of sets and construct fractal interpolation functions.
- Understand the hidden variable fractal interpolation function, fractal splines and fractal surfaces.

Unit 1 Classical Fractals, Self-similarity - Metric Spaces, Equivalent Spaces.

Unit 2 The Space of Fractals, Transformation on Metric Spaces.

Unit 3 Contraction Mapping and Construction of fractals from IFS.

Unit 4 Fractal Dimension, Hausdorff measure and dimension, Fractal Interpolation Functions.

Unit 5 Hidden Variable FIF, Fractal Splines, Fractal Surfaces, Measures on Fractals.

TEXT BOOKS

- *M.F. Barnsley, Fractals Everywhere, Academic Press, 1993.*
- *P.R. Massopust, Interpolation and Approximation with Splines and Fractals, Oxford University Press, 2009.*
- *K. Falconer, Fractal Geometry (Mathematical Foundations and Applications), John Wiley & Sons, 2003.*

REFERENCES

1. P.R. Massopust, Fractal Functions, Fractal Surfaces and Wavelets, Academic Press, 1994.
2. Heinz-Otto Peitgen and Peter Richter, The Beauty of Fractals, Springer, 1986.
3. Richard M. Crownover, Introduction to Chaos and Fractals, Jones and Bartlett Publishers, 1995.
4. Gerald A. Edgar, Measure, Topology and Fractal Geometry, Springer, 1990.
5. M.F. Barnsley, Superfractals, Academic Press, 2006.
6. B.B. Mandelbrot, The Fractal Geometry of Nature, Freeman, 1981.

Evaluation Pattern – R.13 & R.16

15 MAT644 HARMONIC ANALYSIS 3 0 0 3

Unit 1 Fourier series and integrals – Definitions and easy results – The Fourier transform – Convolution – Approximate identities – Fejer's theorem – Unicity theorem – Parselval relation – Fourier Stieltjes Coefficients – The classical kernels.

Unit 2 Summability – Metric theorems – Pointwise summability – Positive definite sequences – Herglotz;s theorem – The inequality of Hausdorff and Young.

Unit 3 The Fourier integral – Kernels on R. The Plancherel theorem – Another convergence theorem – Poisson summation formula – Bachner's theorem – Continuity theorem.

Unit 4 Characters of discrete groups and compact groups – Bochners' theorem – Minkowski's theorem.

Unit 5 Hardy spaces - Invariant subspaces – Factoring F and M. Rieza theorem – Theorems of Szego and Beuoling.

TEXT BOOK:

Content and Treatment as in Henry Helson, Harmonic Analysis, Hindustan Book Agency, Chapters 1.1 to 1.9, 2.1 to 3.5 and 4.1 to 4.3

Evaluation Pattern – R.13 & R.16

15MAT644 NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS 3 0 0 3

CO1- Understand the general concept of weak solution and the criterion of having weak solution for hyperbolic equation.
CO2- Able to model the basic diffusion processes and understand the mathematical methods that are useful in studying the structure of their solutions.
CO3-Understand the existence and uniqueness of traveling wave solutions solutions.
CO4-Understand the concept of nonlinear eigenvalue problem the stability of equilibrium solutions for reaction-diffusion equation.
CO5-Understand the formulation of system of PDEs and their applications.

16MAT645 WAVELETS ANALYSIS 3 0 0 3

Course Out Comes:

CO1 Understand and apply the concepts of DFT and its significance in Engineering problems
CO2 Understand and apply the concept of first stage wavelet basis and iterative stages of wavelet bases in finite dimensional space.
CO3 Understand and apply the concept of first stage wavelet basis and iterative stages of wavelet bases in infinite dimensional space.
CO4 Understand the concepts of Fourier transform and MRA and the construction of wavelets and its applications.

Unit 1 Basic Properties of the Discrete Fourier Transform, Translation - Invariant Linear Transformations. The Fast Fourier Transform.

Unit 2 Construction of Wavelets on , The First Stage Construction of Wavelets on , The Iteration Step"s. Examples and Applications,

Unit 3 Complete Orthonormal Sets in Hilbert Spaces, and Fourier Series, The Fourier Transform and Convolution on First-Stage Wavelets on
The Iteration Step for Wavelets on Z , Implementation and Examples.

Unit 4 and Approximate Identities, The Fourier Transform on , Multiresolution Analysis and Wavelets,

Unit 5 Construction of Multiresolution Analyses, Wavelets with Compact Support and Their Computation.

TEXT BOOK:
Michael W. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer, 1999.

REFERENCES:
- *Daubechis, Ten Lectures on Wavelets, SIAM, 1992.*
- *S. Mallat, A Wavelet Tour of Signal Processing, Elsevier, 2008.*

Evaluation Pattern – R.13 & R.16

15MAT646 MATHEMATICAL PHYSICS 3 0 0 3
Course Out Comes:

Objective*: This course intends to introduce applications of various mathematical techniques to problems of Theoretical Physics. Examples could be chosen from all 4 traditional divisions of Modern Fundamental Theoretical Physics – Classical Mechanics, Electrodynamics, Quantum Mechanics and Statistical Physics.*

Unit 1
Vector calculus and applications in electromagnetic theory and fluid mechanics.

Unit 2
Introduction to tensor calculus: review of basics, index notation, tensors in physics and geometry, Levi-Civita tensor, transformations of vectors, tensors and vector fields, covariance of laws of physics.

Unit 3
Calculus of variations and extremal problems, Lagrange multipliers to treat constraints, Introduction to the Lagrangian and Hamiltonian formulations of classical mechanics with applications.

Unit 4
Gamma and Beta functions, Dirac delta function, Special functions, Review of Legendre, Bessel functions and spherical harmonics (with applications to Quantum mechanics), series solutions, generating functions, orthogonality and completeness,

Unit 5

Applied linear algebra: Dirac notation, dual vectors, projection operators, symmetric hermitian, orthogonal and unitary matrices in physics, diagonalization, orthogonality and completeness of eigenvectors, spectral decomposition and representation, simultaneous diagonalization, normal matrices, applications to coupled vibrations, Schrodinger equation in matrix form.

TEXT BOOKS:

- *Arften and Weber, Mathematical Methods for Physics, Elsevier, 6th Ed., 2005.*
- *Riley, Hobson and Bence, Mathematical Methods for Physics and Engineering, Cup, 3rd Edition, 2010.*

Evaluation Pattern – R.13 & R.16

15MAT651 QUEUING THEORY AND INVENTORY CONTROL THEORY 3 0 0 3

Unit 1 Inventory concept – Components of Inventory model.

Unit 2 Deterministic Continuous Review model - Deterministic Periodic Review model.

Unit 3 The classical EOQ – Non zero lead time – EOQ with shortages allowed.

Unit 4 Deterministic Multiechelon Inventory models for supply chain management.

Unit 5
A stochastic continuous review model – A stochastic single period model for perishable products.

TEXT BOOKS

1. F S Hillier and Gerald J Lieberman, Introduction to Operations research, 8th edition, McGraw Hill.
2. Ravindran, Phillips and Solberg, Operations research Principles and Practice, 2nd Edition, John Wiley & Sons.

Evaluation Pattern – R.13 & R.16

15MAT652 Random Processes 4 0 0 4

Course Outcomes:

- Understand the concepts of stochastic process, markov chains and classifical of states and chains.
- Understand the markov process with discrete state space as poisson process and its properties with related theorems.
- Understand the markov process with continuous state space as wiener process and its properties.
- Understand the renewal process and related theorems.

- Understand the concepts of branching process and Bellman-Harris process.

Probability and Statistics:
Review of one and two random variables, stochastic independence of random variables, Poisson, uniform, exponential and normal distributions, Chebyshev's theorem central limit theorem, transformation of random variables, covariance and correlation, bivariate normal distribution function.

Random Processes:
Random variable and random function – definition of random process – probability distributions and statistical averages Stationarity of random process- Types of stationarity – strict sense and wide sense stationary processes - autocorrelation – properties of autocorrelation and cross-correlation functions – correlation coefficient of stationary process – Binomial and Poisson processes - Poisson points, properties and theorems on Poisson process - Gaussian processes- description of normal processes, first and second order normal processes, standard normal process, processes depending on Gaussian process, random walk and Wiener process - spectrum estimation- Ergodicity, ensemble and time averages, types of ergodic processes - mean ergodic theorem,- Power spectrum – power spectral density function and properties, Wiener-Khinchine theorem, systems with stochastic inputs - Markov process –Markov chains, transition diagram, transition probability matrix, Chapman-Kolmogorov theorem, – steady state probabilities, limiting distributions– classification of states.

TEXT BOOKS and REFERENCES:

1. Douglas C.Montgomery and George C. Runger, "Applied Statistics and probability for Engineers", Third Edition, John Wiley and Sons Inc., 2003.
2. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.
3. A. Papoulis and Unnikrishna Pillai, "Probability, Random Variables and Stochastic processes", Fourth Edition, McGraw Hill, 2002.
4. J. Ravichandran, "Probability and Random Processes for Engineers", First Edition, IK International, 2015

Evaluation Pattern – R.13 & R.16

Learning Outcomes:
Requirement for *Teaching Profession.* **Random processes** are used to model random experiments that evolve in time: This component is useful to understand the concepts of stochastic process, markov chains and classifical of states and chains.Understand the markov process with discrete state space as poisson process and its properties with related theorems. Understand the markov process with continuous state space as wiener process and its properties. Understand the renewal process and related theorems.Understand the concepts of branching process and Bellman-Harris process.

15MAT653 STATISTICAL PATTERN CLASSIFICATIONS 3 0 0 3

Course Out Comes:

CO1 To gain knowledge about pattern classification and dimensionality reduction method

CO2 To understand the use of Maximum-likelihood and Bayesian Parameter Estimation
CO 3 To understand and apply Nonparametric Techniques and Linear Discriminant Functions
CO4 To apply Nonmetric methods and Algorithm-independent Machine Learning
CO5 To implement clustering methods under unsupervised learning

Unit 1 Introduction and Bayesian Decision Theory
Introduction – Pattern recognition systems – the design cycle – learning and adaptation – Bayesian decision theory – continuous features – Minimum error rate classification – discriminant functions and decision surfaces – the normal density based discriminant functions.

Unit 2 Maximum-likelihood and Bayesian Parameter Estimation
Maximum likelihood estimation – Bayesian estimation - Bayesian parameter estimation – Gaussian case and general theory – problems of dimensionality – components analysis and discriminants – hidden Markov models.

Unit 3 Nonparametric Techniques and Linear Discriminant Functions
Nonparametric techniques – density estimation – Parzen windows – nearest neighborhood estimation – rules and metrics – linear discriminant functions and decision surfaces – generalized linear discriminant functions – two-category linearly separable case – minimizing the perception criterion function.

Unit 4 Nonmetric methods and Algorithm-independent Machine Learning
Nonmetric methods – decision trees – CART methods – algorithm-independent machine learning – lack of inherent superiority of any classifier – bias and variance for regression and classification – resampling or estimating statistics – estimating and comparing classifiers.

Unit 5 Unsupervised Learning and Clustering
Unsupervised learning and clustering – mixture densities and identifiability – maximum likelihood estimates – application to normal mixtures – unsupervised Bayesian learning – data description and clustering – criterion functions for clustering – hierarchical clustering – component analysis – low-dimensional representations and multi-dimensional scaling.

TEXT AND REFERENCE BOOKS:

1. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern Classification, Second Edition, 2003, John Wily & Sons.
2. Earl Gose, Richard Johnson baugh and Steve Jost, Pattern Recognition and Image Analysis, 2002, Prentice Hall of India.

Evaluation Pattern – R.13 & R.16

15MAT654 STATISTICAL QUALITY CONTROL AND SIX SIGMA QUALITY ANALYSIS 3 0 0 3
Course Out Comes:

CO1 To develop basic knowledge about TQM
CO2 To understand old and new quality improvement tools
CO3 To understand the aspects of project planning and capability analysis
CO4 To understand the concept of Six Sigma and Lean methods
CO5 To apply Taguchi methods

Unit 1 Introduction to Quality Management – Japanese System of Total Quality Management.

Unit 2 Quality Circles - 7 Quality Control tools - 7 New Quality Control tools.

Unit 3 ISO 9000 Quality system Standards - Project Planning, Process and measurement system capability analysis - Area properties of Normal distribution.

Unit 4 Metrics of Six sigma, The DMAIC cycle - Design for Six Sigma - Lean Sigma – Statistical tools for Six Sigma.

Unit 5 Taguchi methods. Loss functions and orthogonal arrays and experiments.

TEXT AND REFERENCE BOOKS

- *Ravichandran. J, Probability and Statistics for Engineers, 1st Edition 2012 (Reprint), Wiley India.*
- *Montgomery Douglas C., Introduction to Statistical Quality Control, Sixth Edition. John Wiley & Sons, (2008).*
- *Ishikawa K., Guide to Quality Control, 2nd Edition: Asian Productivity Organization, Tokyo (1983).*
- *Taguchi G, Introduction to Quality Engineering: Designing Quality into Products and Processes Second Edition. (1991).*
- *Harry, M and Schroeder R., Six Sigma: The Breakthrough Management Strategy. Currency Publishers, USA. (2000).*

Evaluation Pattern – R.13 & R.16

15MAT655 THEORY OF SAMPLING AND DESIGNS OF EXPERIMENTS 3 0 0 3

Course Out Comes:

CO1 To study different types of basic sampling methods
CO2 To understand the types of estimators and their applications
CO3 To understand with and without replacement sampling methods
CO4 To understand the use of sampling in experimental designs
CO5 To apply factorial experiments

Unit 1

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and srs. Systematic sampling. Comparison of systematic sampling - srs and stratified random sampling for a population with a linear trend.

Unit 2

Unbiased ratio type estimators - Hartley-Ross estimator, regression method of estimation. Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two-stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error.

Unit 3

Unequal probability sampling, PPS sampling with and without replacement, cumulative total method, Lahiris method, Midzuno-Zen method, estimation of the population total and its estimated variance under PPS wr sampling, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator.

Unit 4

Elementary concepts (one and 2 way classified data) Review of elementary design (CRD, RBD, LSD) Missing plot technique in RBD and LSD with one and two missing values, Gauss-Markov theorem, BIBD: Elementary parametric relations, Analysis, PBIBD.

Unit 5

General factorial experiments, factorial effects, best estimates and testing the significance of factorial effects, study of 2^3 and 2^4 factorial experiments.

TEXT AND REFERENCE BOOKS

1. Cochran, W.C. Sampling Techniques, Third Edition, Wiley Eastern, (1977).
2. Des Raj, Sampling Theory, Tata McGraw Hill, New Delhi, (1976).
3. Murthy, M.N., Sampling Theory, Tata McGraw Hill, New Delhi, (1967).

Evaluation Pattern – R.13 & R.16

15MAT656 TIME SERIES ANALYSIS 3 0 0 3

Course Out Comes:

CO1 To gain in-depth knowledge about time series and its components
CO2 To understand the smoothening concepts and the relevant tests.
CO3 To understand and apply the concepts of autocorrelation and autocovariance
CO4 To apply various types of autoregressive models
CO5 To understand the estimation procedures in time series

Unit 1 Time series, components of time series, additive and multiplicative models, determination of trend, analysis of seasonal fluctuations.

Unit 2 Test for trend and seasonality, exponential and moving average smoothing, holt-winter smoothing, forecasting based on smoothing.

Unit 3 Time series as a discrete parameter stochastic process, auto covariance and auto correlation functions and their properties, stationary processes, test for stationarity, unit root test, stationary processes in the frequency domain, spectral analysis of time series.

Unit 4 Detailed study of the stationary processes: moving average (MA), autoregressive (AR), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.

Unit 5 Estimation of ARMA models, maximum likelihood method (the likelihood function for a Gaussian AR(1) and a Gaussian MA(1)) and Least squares, Yule-Walker estimation for AR Processes, choice of AR and MA periods, forecasting, residual analysis and diagnostic checking.

TEXT BOOKS

1. Anderson, T.W. The Statistical Analysis of Time Series, John Wiley, New York, 1971.
2. Box, G.E.P. and Jenkins, G.M. Time Series Analysis- Forecasting and Control, Holden-day, San Francisco,1976.
3. Kendall, Sir Maurice and Ord, J.K., Time Series, Edward Arnold, London, 1990.

Evaluation Pattern – R.13 & R.16

15MAT645 WAVELETS ANALYSIS 3 0 0 3

Course Out Comes:

Unit 1

Introduction – limitations of ideal fluid dynamics – Importance of Prandtl's boundary layer theory - boundary layer equations in two dimensional flows – boundary layer flow over a flat plate – Blasius solution – Boundary layer over a wedge.

Unit 2

Energy integral equation for two-dimensional laminar boundary layers in incompressible flow – application of Von Karman's integral equations to boundary layer with pressure gradient.

Unit 3

Displacement, momentum, energy thickness – axially symmetric flows – momentum equation for laminar boundary layer by von Karman – Wall shear and drag force on a flat plate due to boundary layer – coefficient of drag. Boundary layer equations for a 2D viscous incompressible fluid over a plane wall – Similar solutions – Separation of boundary layer flow.

Unit 4

Hydromagnetic Boundary layers – Hartman Layer – MHD Blasius flow. Thermal boundary layers – thermal boundary layer equation in two dimensional flow – Thermal boundary layers with and without coupling of velocity and temperature field – forced convection in a laminar boundary on a flat plate.

Unit 5

Polhausen's method of exact solution for the velocity and thermal boundary layers in free convection from a heated plate – thermal energy integral equation. Boundary layer control using suction and injection.

TEXT BOOKS / REFERENCES:

1. H.Schlichting and K.Gersten, "Boundary Layer Theory", Eighth Edition, Springer, 2000.
2. L. Rosenhead, "Laminar Boundary Layers", Dover, 1988.
3. G.K.Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press,1993.
4. P.H.Roberts , "An Introduction to MHD" , Longmans, 1967.

Evaluation Pattern – R.13 & R.16

15MAT662 COMPUTATIONAL FLUID DYNAMICS 3 0 0 3

Course Out Comes:

CO-01: To review the conservation laws and to understand the Eulerian and Lagrangian approach to fluid flow problems
CO-02: To understand the classification of PDEs and to review Finite Difference, Integral, Weighted Residual and Finite Element and Finite Volume and Least Square Methods
CO-03: To understand the finite volume discretization method and to develop computational methods for compressible flows
CO-04: To learn advance notions of finite volume methods and apply SIMPLE algorithm for flow and model and solve turbulent flows
CO-05 : To learn CFD methods for compressible and turbulent flows

2. Ferziger, J. H. and Peric, M., Computational Methods for Fluid Dynamics, 3rd edition, Springer. 2003.

Evaluation Pattern – R.13 & R.16

15MAT663 FINITE ELEMENT METHOD 3 0 0 3

Course Out Comes:

CO-1: Understand the basic concepts of weighted residue and energy methods.
CO-2: Understand the concepts of global and local finite element models and its derivations.
CO-3: Application of interpolation and various polynomials to model stiffness matrices.
CO-4: Application of global and local finite element models with boundary conditions in a steady state problem.
CO-5: Usage of finite element concept for one dimensional heat and wave equations.

Unit 1 Finite Element Method: Variational formulation - Rayleigh-Ritz minimization - weighted residuals - Galerkin method applied to boundary value problems.

Unit 2 Global and local finite element models in one dimension - derivation of finite element equation.

Unit 3 Finite element interpolation - polynomial elements in one dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite

elements for rectangular elements - global interpolation functions.

Unit 4 Local and global forms of finite element equations - boundary conditions - methods of solution for a steady state problem - Newton-Raphson continuation.

Unit 5 One dimensional heat and wave equations.

TEXT AND REFERENCE BOOKS

- *J.N .Reddy, An Introduction to the Finite Element Method, McGraw Hill, NY.*
- *Chung, Finite Element Analysis in Fluid Dynamics, McGraw Hill Inc.*

Evaluation Pattern – R.13 & R.16

15MAT664 MAGNETO-HYDRO DYNAMICS 3 0 0 3

Course Out Comes:

CO-01 : To understand the basic electromagnetic equations, MHD equations, magnetic stresses, induction equations and Alfven's Theorem and its application to Ferraro's Law of Isorotation.
CO-02: To understand magnetohydro statics, force-free magnetic fields and Chandrasekhar's theorem on fields with ohmic dissipation.
CO-03: To understand the effect of transverse magnetic field on flow between parallel plates (Hartman Flow) and the Hall effects
CO-04: To understand Alfven Waves in Incompressible and Compressible Flows and to apply Squire' Theorem to develop Rayleigh's Stability Equation and Orr-Somerfield Equation for the viscous fluid
CO-05: To understand Bertein's method of small oscillations and Chandrasekhar's generalization of Jean's Criteria for gravitation stability.

Unit 1

Electromagnetic field equations – Maxwell's equations - Electromagnetic effects and the magnetic Reynolds number – induction equation. Alfven's Theorem – Ferraro's Law of irrotation – Electromagnetic stresses.

Unit 2

Magnetohydrostatics and steady states – Hydromagnetic equilibria and Force free magnetic fields — Chandrasekhar's theorem – General solution of force free magnetic field when**Error! Objects cannot be created from editing field codes.** is constant – Some examples of force free fields.

Unit 3

Steady laminar motion – Hartmann flow. Tensor electrical conductivity, Hall current and ion slip – simple flow problems with tensor electrical conductivity.

Unit 4

Magnetohydrodynamic waves - Alfven waves – Stability of hydromagnetic systems - Normal mode analysis - Squire's theorem – Orr-Sommerfield equation – Instability of linear pinch – Flute instability – A general criterion for stability.

Unit 5 Bernstein's method of small oscillations – Jeans Criterion for Gravitational stability – Chandrasekhar's generalization for MHD and rotating fluids.

TEXT BOOKS / REFERENCES:

1. Ferraro, V.C.A and Plumpton, C., "An Introduction to Magneto-Fluid Mechanics", Clarendon Press, Oxford, 1966.

2. M.R. Crammer, and Shi-I Pai, "Magneto-Fluid Dynamics for Engineers and Applied Physicists", Scripta Publishing Company, Washington, 1973.

3. P.H. Roberts, "An Introduction to Magnetohydrodynamics", Longmans, Green and Co, London, 1967.

4.S. Chandrasekhar, "Hydrodynamic and Hydromagnetic Stability", Dover Publications, 1981.

Evaluation Pattern – R.13 & R.16

15MAT665 MATHEMATICAL FOUNDATIONS OF INCOMPRESSIBLE FLUID FLOW 3 0 0 3

Course Out Comes:

Unit 1 Kinematics of Fluids in motion – Lagrangian and Eulerian methods – Equation of continuity – Boundary conditions – Kinematic and physical – steam line, path line and streak line – velocity potential – vorticity - rotational and irrotational motion.

Unit 2 Equation of Motion of Compressible Viscous Fluid (Navier-Stokes Equations) - General Properties – Equation of motion of inviscid fluid – Euler's equation – impulsive force – physical meaning of velocity potential - energy equation.

Unit 3 Lagrange's hydrodynamical equations - Bernoulli's equation and its applications - Motion in two-dimensions and sources and sinks – irrotational motion – complex potential - Milne-Thomson circle theorem – Blasius theorem.

Unit 4 General theory of irrotational motion – flow and circulation – Stoke's theorem – Kelvin's Circulation theorem – Permanence of irrotational motion - Kelvin's minimum energy theorem - Viscous Incompressible flow - Dimensional Analysis – Buckingam**Error! Objects cannot be created from editing field codes.** theorem.

Unit 5 Exact Solutions of Navier Stokes Equations – Small Reynold's number flows – flow past a sphere – Stokes flow – Whitehead's paradox - Flow past a circular cylinder – Stoke's Paradox.

TEXT BOOKS / REFERENCES:

1. G.K. Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press, 1997.

2. L.M. Milne-Thompson, "Theoretical Hydrodynamics", Dover Publications, 1968.

3. Victor L. Streeter and E. Benjamin Wylie, "Fluid Mechanics", Mc Graw Hill, 1983.

4. S.W. Yuan, "Foundations of Fluid Mechanics", Prentice Hall, New Jersey, 1970.

Evaluation Pattern – R.13 & R.16

15MAT671 DATA STRUCTURES AND ALGORITHMS 3 0 0 3

Course Out Comes:

CO-1: Understand the basic concepts of growth functions and various sortings.
CO-2: Understand and the concept of divide and conquer for various sortings.
CO-3: Understand and apply the greedy method for various problems.
CO-4: Understand various definitions of graphs and apply to some algorithms.
CO-5: Understand the concepts of various computational complexity classes.

Unit 1 Introduction: growth functions – recurrence relation – methods – master method. Sorting: bubble – insertion sort – selection sort.

Unit 2 Divide and conquer: quick sort – merge sort – bucket sort – lower bounds – heap sort – comparisons of sorting.

Unit 3 Greedy algorithm: fractional knapsack problem – task scheduling problem. Dynamic programming: matrix multiplication problem – 0-1 knapsack.

Unit 4 Graph algorithms: graph traversal (DFS, BFS with analysis) – biconnected components – strong connectivity; shortest path algorithms (along with analysis) – Dijkstra – Bellman Ford – Floyd Warshall. All pairs shortest path algorithm – minimum spanning tree (with analysis) – Kruskal – Prim's – Baruvka's.

Unit 5

NP problems: definition, P, NP, NP complete, NP hard & co-NP, examples – P, NP.

TEXT BOOK

Goodrich M T and Tamassia R, Algorithm Design Foundations, Analysis, and Internet Examples, John Wiley and Sons, 2002.

REFERENCES

- *Baase S and Gelder A V, ``Computer Algorithms – Introduction to Design and Analysis, Pearson Education Asia, 2002.*
- *Cormen T H, Leiserson C E, Rivest R L and Stein C, Introduction to Algorithms, Prentice Hall of India Private Limited, 2001.*
- *Dasgupta S, Papadimitriou C and Vazirani U, Algorithms, Tata McGraw-Hill, 2009.*
- *Horowitz E, Sahni S and Rajasekaran S, Fundamentals of Computer Algorithms, Galgotia, 1998.*

Evaluation Pattern – R.13 & R.16

15MAT673 COMPUTER AIDED DESIGN OF VLSI CIRCUITS 3 0 0 3

Course Out Comes:

CO-1: Understand the basic concepts of VLSI design problems.

CO-2: Understand various definitions of graphs and apply to some algorithms.
CO-3: Understand and apply the placement and partitioning algorithms.
CO-4: Understand and apply the routing algorithms.
CO-5: Understand the concepts of 1D and 2D compactions.

Unit 1
Introduction of Design Methodologies and Graph Theory: The VLSI Design Problems - Design Methods – Design Cycle – Physical Design Cycle - Design Styles.

Unit 2
Algorithmic and System Design - Structural and Logic Design - Layout Design. Graph terminologies – Data structures for the representation of Graphs – Algorithms: DFS – BFS - Dijkstra's shortest path algorithm – Prim's algorithm for minimum spanning trees. Combinatorial Optimization Problems – Complexity Class – P - NP Completeness and NP Hardness problems.

Unit 3
Placement, Partitioning and Floor Planning: Types of Placement Problems – Placement Algorithms – K-L Partitioning Algorithm. Optimization Problems in Floor planning - Shape Function and Floor plan Sizing.

Unit 4
Routing and Compaction: Types of Routing Problems – Area Routing – Channel Routing – Global Routings.

Unit 5 1D and 2D Compaction. Gete level – Switch level Modeling and Simulations.

TEXT BOOK / REFERENCES:

- *Gerez, "Algorithms for VLSI Design Automation", John Wiley & Sons, 2000.*
- *Naveed Sherwani, "Algorithms for VLSI Physical Design Automation", Second Edition, Kluwer Academic Publishers, 1995.*
- *Sadiq M Sait and Habib Youssef, "VLSI Physical Design Automation: Theory and Practice", IEET, 1999.*
- *M. Sarrafzadeh and C. K. Wong, An Introduction to VLSI Physical Design,*

McGraw- Hill, New York, NY, 1996.
- *Giovanni De Micheli, Synthesis and Optimization of Digital Circuits, Tata McGraw Hill, 1994*

Evaluation Pattern – R.13 & R.16

15MAT672Advanced Graph Theory 3 0 0 3

CO-1: Understand the basic concepts of graphs and Line Graphs

CO-2: Understand and apply the concepts of matrices and groups in graphs

CO-3: Understand and apply the concepts of matching problems and factorization.

CO-4: Understand the concepts of vertex and edge colorings.

CO-5: Understand the concepts of planar graphs and dual graphs.

Unit-I Binomial coefficients, convexity. Inequalities: Jensen's, AM-GM, Cauchy Schwarz. Graphs, subgraphs, connectedness.

Unit-II Euler circuits, cycles, trees, bipartite graphs and other basic concepts.

Unit-III Vertex colourings. Graphs with large girth and large chromatic number.

Unit-IV Extremal graph theory: Dirac's theorem. Ore's theorem. Mantel's theorem. Turan's theorem (several proofs including probabilistic and analytic).

Unit-V Kovari- Sosuran theorem with applications to geometry. Erdos Stone theorem. Stability. Andrasfai-Erdos-Sos theorem.

TEXT AND REFERENCE BOOKS

1. B Bollobas, Modern Graph Theory, Springer
2. D.B. West, *Introduction to Graph Theory*, P.H.I. 2010

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

Requirement for Teaching Profession. It uses in the *application* of problem solving in the fields of psychology and *graph theory*. An *application* of matching in *graph theory* shows that there is a common set of left and right. *Advanced Graph Theory* focuses on some of the main notions arising in *graph theory* with an emphasis from the very start of the book on the possible applications of the *theory* and the fruitful links existing with linear algebra.

15MAT674 CRYPTOGRAPHY 3 0 0 3

Course Out Comes:

CO-1: Understand the basic concepts of classical ciphers.
CO-2: Understand the concepts of encryptions and pseudorandomness.
CO-3: Understand the concepts private-key encryption.
CO-4: Understand the concepts of ElGamal encryption.
CO-5: Understand the concepts of RSA and DSA signatures.

Unit 1 Classical ciphers: Cryptanalysis of classical ciphers, Probability theory, Perfect security. **Block ciphers:** DES, AES, Block cipher modes of operation.

Unit 2 Private-key encryption: Chosen plaintext attacks, Randomised encryption, Pseudorandomness, Chosen cyphertext attacks.

Unit 3 Message authentication codes: Private-key authentication, CBC-MAC, Pseudorandom functions, CCA-secure private-key encryption.

Unit 4 Hash function: Integrity, Pre-image resistance, 2nd pre-image resistance, Collision freeness. **Key distribution:** Key distribution centres, Modular arithmetic and group theory, Diffie-Hellman key exchange.

Unit 5 Public-key Distribution: EIGamal encryption, Cramer-Shoup encryption, Discrete logarithm problem.
Digital Signatures: RSA signatures, RSA-FDH and RSA-PSS signatures, DSA signatures.

TEXT / REFERENCE BOOKS:

1. Katz and Lindell, Introduction to Modern Cryptography. Second Edition, Chapman & Hall/ CRC Press, 2014.
2. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press.
3. Hans Delfs, Helmut Knebl, "Introduction to Cryptography, Principles and Applications", Springer Verlag.

Evaluation Pattern – R.13 & R.16

15MAT675 FUZZY SETS AND ITS APPLICATIONS 3 0 0 3

Course Out Comes:

CO-1: Understand the basic concepts of Fuzzy sets
CO-2: Understand the concepts of arithmetci operations on fuzzy numbers.
CO-3: Understand the concepts Fuzzy relations.
CO-4: Understand the concepts of Fuzzy logic.
CO-5: Understand the concepts of uncertainty and crisp sets.

Unit 1 Fuzzy Sets

Crisp Sets - an Overview, Fuzzy Sets - Definition and Examples, α - Cuts and its Properties, Representations of Fuzzy Sets, Extension Principles of Fuzzy Sets, Operations on Fuzzy Sets - Fuzzy Complements, Fuzzy Intersections, Fuzzy Unions, Combinations of Operations, Aggregation Operations.

Unit 2 Fuzzy Arithmetic

Fuzzy Numbers, Arithmetic Operations on Intervals, Arithmetic Operations on Fuzzy Numbers.

Unit 3 Fuzzy Relations

Binary Fuzzy relations, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations.

Unit 4 Fuzzy Logic
Classical Logic, Multivalued Logic, Fuzzy Propositions, Fuzzy Quantifiers, Linguistic Hedges, Inference from Conditional Fuzzy Propositions, Conditional and Qualified Propositions and Quantified Propositions.

Unit 5 Uncertainty-based Information
Information and Uncertainty, Non Specificity of Crisp Sets – Non Specificity of Fuzzy Sets, Fuzziness of Fuzzy Sets, Uncertainty In Evidence Theory, Principles of Uncertainty.

TEXT AND REFERENCE BOOKS:

- *George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic- Theory and Applications, Prentice Hall of India, 1997.*
- *Timothy J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill, 1997.*
- *H.J. Zimmermann, Fuzzy Sets and its Applications, Allied publishers, 1991.*

Evaluation Pattern – R.13 & R.16

15MAT676 INTRODUCTION TO SOFT COMPUTING 3 0 0 3

Course Out Comes:

CO-1: Understand the various types of soft computing techniques
CO-2: Understand the concepts of artificial intelligence.
CO-3: Understand and apply the concepts fuzzy logic in optimization problems.
CO-4: Understand the concepts of neural networks.
CO-5: Understand the concepts of genetic algorithms.

Unit 1 Soft Computing
Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing.

Unit 2 Artificial Intelligence
Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies.

Unit 3 Fuzzy Logic
Crisp set and Fuzzy set, basic concepts of fuzzy sets, membership functions. Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations. Propositional logic and Predicate logic, fuzzy If - Then rules, fuzzy mapping rules and fuzzy implication functions, Applications.

Unit 4 Neural Networks
Basic concepts of neural networks, Neural network architectures, Learning methods, Architecture of a back propagation network, Applications.

Unit 5 Genetic Algorithms
Basic concepts of genetic algorithms, encoding, genetic modeling.
Hybrid Systems: Integration of neural networks, fuzzy logic and genetic algorithms.

TEXT AND REFERENCE BOOKS

- *S. Rajasekaran and G. A. Vijaylakshmi Pai. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.*
- *K. H. Lee. First Course on Fuzzy Theory and Applications, Springer-Verlag.*
- *J. Yen and R. Langari. Fuzzy Logic, Intelligence, Control and Information, Pearson Education.*

Evaluation Pattern – R.13 & R.16

15MAT677 OBJECT- ORIENTED PROGRAMMING AND PYTHON 3 0 0 3

Course Out Comes:
CO-1: Understand the various classes in C++
CO-2: Understand the concepts of constructors and operators in C++
CO-3: Understand and apply the concepts functions for some problems.
CO-4: Understand the concepts of RTTI typeid dynamic casting.
CO-5: Understand and practice the Python programming.

Unit 1 Object-oriented programming concepts – objects – classes – methods and messages – abstraction and encapsulation – inheritance – abstract classes – polymorphism.

Introduction to C++ – classes – access specifiers – function and data members – default arguments – function overloading – friend functions – const and volatile functions - static members – Objects - pointers and objects – constant objects – nested classes – local classes.

Unit 2 Constructors – default constructor – Parameterized constructors – Constructor with dynamic allocation – copy constructor –destructors – operator overloading – overloading through friend functions – overloading the assignment operator – type conversion – explicit constructor.

Unit 3 Function and class templates - Exception handling try-catch-throw paradigm – exception specification – terminate and Unexpected functions – Uncaught exception.

Unit 4 Inheritance – public, private, and protected derivations – multiple inheritance - virtual base class – abstract class – composite objects Runtime polymorphism – virtual functions – pure virtual functions – RTTI – typeid – dynamic casting – RTTI and templates – cross casting – down casting.

Unit 5 Python Programming.

TEXT BOOK

1. B. Trivedi, "Programming with ANSI C++", Oxford University Press, 2007.

REFERENCES BOOKS

1. Ira Pohl, "Object Oriented Programming using C++", Pearson Education, Second Edition Reprint 2004.

2. S. B. Lippman, Josee Lajoie, Barbara E. Moo, "C++ Primer", Fourth Edition, Pearson Education, 2005.

3. B. Stroustrup, "The C++ Programming language", Third edition, Pearson Education, 2004.

Evaluation Pattern – R.13 & R.16

15MAT657 STATISTICAL TECHNIQUES FOR DATA ANALYTICS 3-0-0-3

Course Out Comes:

CO1:Understand the basic idea of data analysis

CO2:Ability to interpret the data graphically

CO3:Understand the relation ship between two datas graphically

Co4: understand the Idea of trend analysis

CO5:Understand the method of solving Game problems.

Data Collection, classification and analysis - Sampling methods, classification of data and representation of data- bar and pie charts – histogram frequency polygon - Data Analysis Measures of Central tendency and dispersion - Mean, median, mode, absolute, quartile and standard deviations, skewness and kurtosis for both grouped and ungrouped data. Association of attributes.

Curve fitting and interpolation - Fitting of straight lines and curves - Correlation, regression, fitting of simple linear lines, polynomials and logarithmic functions - Interpolation and extrapolation methods - Binomial expansion, Newton and Gauss methods.

Index numbers and time series analysis - Types of index numbers, construction of index numbers such as simple aggregate, weighted aggregate index numbers, chain index numbers and consumer price indices - Time series and its components and computation of trends and variations - Seasonal variations - Trend analysis methods.

Decision analysis and Game theory - Payoffs, regrets, maximin and minimax criteria and loss and risks – Games – payoff matrix, saddle point, value of game and methods of solving – two-person-zero-sum games, dominance method, sub-game method

Text Books:

- *Pillai R.S. N. andBagavathi. "Statistics", S. Chand, New Delhi, 2001.*
- *Kanti Swarup, Gupta, P.K., and Man Mohan. "Operations Research" (Chapters 16 and 17), S. Chand, New Delhi, 2001.*

References Book

1. Amir D Aczel, Jayavel Soundarapandian , Palanisamy Saravanan, Rohit Joshi, Complete Business Statistics,7edition,McGraw Hill, New Delhi

Evaluation Pattern – R.13 & R.16

15MAT672 ALGORITHMS FOR ADVANCED COMPUTING 3-0-0-3

Course Out Comes:

CO-1: Understand the various classifications
CO-2: Understand the concepts of decision trees
CO-3: Understand and apply the concepts preprocessing techniques for information extraction problems.
CO-4: Understand the concepts of various soft computing techniques.
CO-5: Understand the concepts of various algorithms in networks.

Unit I Issues regarding classification and prediction, Bayesian Classification, Classification by back propagation, Classification based on concepts from association rule mining, Other Classification Methods, Classification accuracy.

Unit II Introduction to Decision trees - Classification by decision tree induction – Various types of pruning methods – Comparison of pruning methods – Issues in decision trees – Decision Tree Inducers – Decision Tree extensions.

Unit III Introduction, Core text mining operations, Preprocessing techniques, Categorization, Clustering, Information extraction, Probabilistic models for information extraction

Unit IV Soft Computing: Rationale, motivations, needs, basics: examples of applications in diverse fields, Basic tools of soft computing: Neural Networks, Fuzzy Logic Systems, and Support Vector Machines, Statistical Approaches to Regression and Classification - Risk Minimization, Support Vector Machine Algorithms.

Unit V Single-Layer Networks: The Perceptron, The Adaptive Linear Neuron (Adaline) and the Least Mean Square Algorithm - Multilayer Perceptrons: The Error Backpropagation Algorithm – The Generalized Delta Rule, Heuristics or Practical Aspects of the Error Backpropagation Algorithm.

Text Books:

- *Jiawei Han and Micheline Kamber, "Data Mining: Concepts and Techniques", Morgan Kaufmann Publishers, 3rd ed, 2010.*
- *Jared Dean, "Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners", Wiley India Private Limited, 2014.*

References Books :

- *LiorRokach and Oded Maimon, "Data Mining and Knowledge Discovery Handbook", Springer, 2nd edition, 2010.*
- *Ronen Feldman and James Sanger, "The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data", Cambridge University Press, 2006.*
- *Vojislav Kecman, "Learning and Soft Computing", MIT Press, 2010*.

- **Evaluation Pattern – R.13 & R.16**

15CUL501 CULTURAL EDUCATION 2 0 0 P/F

Objectives

The student will be introduced to the foundational concepts of Indian culture and heritage

Course Outcomes: After the completion of the course the student will be able to:

CO1	Gain a positive appreciation of Indian culture, traditions, customs and practices
CO2	Understand the foundational concepts of Indian civilization like purusharthas, law of karma, etc, which contributes towards personality growth.
CO3	Understand the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma's life and vision of holistic education
CO4	Imbibe spirit of living in harmony with nature
CO5	Get guidelines for healthy and happy living from the great spiritual masters

Unit 1

Introduction to Indian Culture - Introduction to Amma's life and Teachings - Symbols of Indian Culture.

Unit 2

Science and Technology in Ancient India - Education in Ancient India - Goals of Life – Purusharthas - Introduction to Vedanta and Bhagavad Gita.

Unit 3

Introduction to Yoga - Nature and Indian Culture - Values from Indian History - Life and work of Great Seers of India.

TEXTBOOKS:

1. *The Glory of India (in-house publication)*
2. *The Mother of Sweet Bliss, (Amma's Life & Teachings)*

Evaluation Pattern – R.13 & R.16

15AVP501 AMRITA VALUES PROGRAMME 1 0 0 1

The student will gain understanding of the glory of Indian Ithihasa (Epics) in general, wherefrom the student get inspired to follow the lifestyle of inspiring characters depicted in Ramayana.

Course Outcomes: After the completion of the course the student will be able to:

CO1	Appreciate the relevance of Ramayana in modern times.
CO2	Understand the family values and ideal human relationships portrayed in the Ramayana.
CO3	Understand Dharma and its universality, emphasizing its applicability in an individual's life.
CO4	Evaluate one's own personal ethics based on benchmarks from the Ramayana
CO5	Apply the spiritual values from Ramayana in resolving personal and social conflicts

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Courses offered under the framework of Amrita Values Programmes I and II

Insights into Indian Classical Music

The course introduces the students into the various terminologies used in Indian musicology and their explanations, like Nadam, Sruti, Svaram – svara nomenclature, Stayi, Graha, Nyasa, Amsa, Thala,- Sapta talas and their angas, Shadangas, Vadi, Samavadi, Anuvadi. The course takes the students through Carnatic as well as Hindustani classical styles.

Insights into Traditional Indian Painting

The course introduces traditional Indian paintings in the light of ancient Indian wisdom in the fields of aesthetics, the Shadanga (Sixs limbs of Indian paintings) and the contextual stories from ancient texts from where the paintings originated. The course introduces the painting styles such as Madhubani, Kerala Mural, Pahari, Cheriyal, Rajput, Tanjore etc.

Insights into Indian Classical Dance

The course takes the students through the ancient Indian text on aesthetics the Natyasastra and its commentary the Abhinava Bharati. The course introduces various styles of Indian classical dance such as Bharatanatyan, Mohiniyatton, Kuchipudi, Odissy, Katak etc. The course takes the students through both contextual theory as well as practice time.

Indian Martial Arts and Self Defense

The course introduces the students to the ancient Indian system of self-defense and the combat through various martial art forms and focuses more on traditional Kerala's traditional Kalari Payattu. The course introduces the various exercise technique to make the body supple and flexible before going into the steps and techniques of the martial art. The advanced level of this course introduces the technique of weaponry.

Social Awareness Campaign

The course introduces the students into the concept of public social awareness and how to transmit the messages of social awareness through various media, both traditional and modern. The course goes through the theoretical aspects of campaign planning and execution.

Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendor of our temples makes art enthusiast spellbound, warmth and grandeur of color combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of

Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the vasthupurusha.

Organic Farming in Practice

Organic agriculture is the application of a set of cultural, biological, and mechanical practices that support the cycling of farm resources, promote ecological balance, and conserve biodiversity. These include maintaining and enhancing soil and water quality; conserving wetlands, woodlands, and wildlife; and avoiding use of synthetic fertilizers, sewage sludge, irradiation, and genetic engineering. This factsheet provides an overview of some common farming practices that ensure organic integrity and operation sustainability.

Ayurveda for Lifestyle Modification:

Ayurveda aims to integrate and balance the body, mind, and spirit which will ultimately leads to human happiness and health. Ayurveda offers methods for finding out early stages of diseases that are still undetectable by modern medical investigation. Ayurveda understands that health is a reflection of when a person is living in harmony with nature and disease arises when a person is out of harmony with the cycles of nature. All things in the universe (both living and non-living) are joined together in Ayurveda. This leaflet endow with some practical knowledge to rediscover our pre-industrial herbal heritage.

Life Style and Therapy using Yoga

Yoga therapy is the adaptation of yogic principles, methods, and techniques to specific human ailments. In its ideal application, Yoga therapy is preventive in nature, as is Yoga itself, but it is also restorative in many instances, palliative in others, and curative in many others. The therapeutic effect comes to force when we practice daily and the body starts removing

Evaluation Pattern – R.13 & R.16