Post - Graduate Programme
in Mathematics

Courses of study, Schemes of Examinations
& Syllabi
(Choice Based Credit System)

THE DEPARTMENT OF MATHEMATICS
(DST – FIST sponsored)
BISHOP HEBER COLLEGE (Autonomous)
(Reaccredited with 'A' Grade (CGPA – 3.58/4.0) by the NAAC &
Identified as College of Excellence by the UGC)
DST – FIST Sponsored &
DBT Sponsored
TIRUCHIRAPPALLI – 620 017
TAMIL NADU, INDIA

2019 – 2020

Post – Graduate Programme in Mathematics

Eligibility : An under graduate degree in Mathematics.

Preference : A high first class in Part III of the UG Curriculum.

Structure of the Curriculum

Parts of the Curriculum	No. of courses	Credits
Core	14	64
Elective	5	20
Project	1	4
VLOC	1	2
Total	**21**	**90**

List of Core Courses

1. Real Analysis
2. Linear Algebra
3. Ordinary Differential Equations
4. Calculus of Variations, Integral Equations & Transforms
5. Algebra
6. Partial Differential Equations
7. Fluid Dynamics
8. Topology
9. Measure and Integration
10. Complex Analysis
11. Probability and Statistics
12. Functional Analysis
13. Numerical Analysis
14. Operations Research
15. Classical Dynamics
16. Algebraic Number Theory
17. Advanced Analysis
18. Rings and Modules

List of Elective Courses

1. Graph Theory
2. Object oriented programming in C++
3. Fuzzy Set Theory and its Applications
4. Data Structures and Algorithms
5. Programming with JAVA
6. Differential Geometry
7. Stochastic Processes
8. Computational Fluid Dynamics
9. Boundary Value Problems
10. MATHLAB
11. Combinatorics

List of Extra Credit Courses offered by the Department:

1. Finite Difference Methods
2. Information Theory
3. Wavelet Theory
4. Theory of Linear Operators
5. Mathematical Physics
6. History of Modern Mathematics
7. Research Methodology

Learning Outcomes of Post-Graduate Programme in Mathematics

General Outcomes	Specific Outcomes
On successful completion of the Programme the student will be 1. strong in logical thinking and reasoning to solve any problem. 2. able to take up any project from the fields of science and engineering.	On successful completion of the Post-Graduate Programme in Mathematics, the student is expected to 1. have acquired strong knowledge in the core areas of Mathematics and applications of Mathematics to continue with research. 2. be proficient in Mathematics to teach it at school and college level. 3. be skillful to take up jobs that require sound knowledge in Mathematics in different private and public sectors.

M.Sc., Mathematics
(For the candidates admitted from the academic year 2019 onwards)

Sem.	Course	Course Code	Course Title	Pre requisites	Hrs./ week	Credits	Marks		
							CIA	ESA	Total
I	Core I	P14MA101	Real Analysis		6	5	25	75	100
	Core II	P14MA102	Linear Algebra		6	5	25	75	100
	Core III	P16MA103	Ordinary Differential Equations		6	4	25	75	100
	Core IV	P16MA104	Calculus of Variations, Integral Equations and Transforms		6	4	25	75	100
	Elective I	P14MA1:1	Graph Theory		6	4	25	75	100
II	Core V	P14MA205	Algebra		6	5	25	75	100
	Core VI	P14MA206	Partial Differential Equations		6	4	25	75	100
	Core VII	P16MA207	Fluid Dynamics	P14MA103	6	5	25	75	100
	Elective II	P16MA2:P	Object Oriented Programming in C++		5	4	40	60	100
	Elective III	P19MA2:1	Fuzzy Set Theory and its Applications		5	4	40	60	100
	VLOC	P17VL2:1 / P17VL2:2	Religious Instructions / Moral Instructions		2	2	25	75	100
III	Core VIII	P14MA308	Topology	P14MA101 P14MA205	6	5	25	75	100
	Core IX	P14MA309	Measure and Integration	P14MA101	6	5	25	75	100
	Core X	P14MA310	Complex Analysis	P14MA101	6	5	25	75	100
	Core XI	P16MA311	Probability and Statistics		6	4	25	75	100
	Elective IV	P19MA3:1/ P19MA3:2/ P19MA3:3	Data Structures and Algorithms / Programming with JAVA / Differential Geometry		6	4	40/ 40/ 25	60/ 60/ 75	100
IV	Core XII	P14MA412	Functional Analysis	P14MA101, P14MA102 P14MA308, P14MA310	6	5	25	75	100
	Core XIII	P14MA413	Numerical Analysis	P14MA103	6	4	25	75	100
	Core XIV	P14MA414	Operations Research		6	4	25	75	100
	Elective V	P14MA4:1	Stochastic Processes	P14MA311	6	4	25	75	100
	Project	P14MA4PJ	Project		6	4	40	60	100
Total						**90**			**2100**

CIA- Continuous Internal Assessment
ESA- End Semester Assessment
VLOC- Value added Life Oriented Course

Core Course I - Real Analysis

Sem. I **Code : P14MA101**
Total Hrs. : 90 **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to understand the real number system as a perfect set
2. be able to understand the continuity of functions and prove how the continuity of functions preserve the properties like the connectedness, compactness etc. of sets.
3. be able to understand the uniform convergence of sequences and series of real functions and nature of the limit functions.
4. be able to analyze the differentiability of various functions and use the differentiability of functions to understand their behavior in the neighborhood of limit points.

Learning outcomes:

On completion of the course, the student will

1. know the structure of the real systems, the metrics, behavior of functions at limit points etc.
2. be able to analyse metric spaces and functions defined on metric spaces.

Unit I

Metric spaces with examples – Neighbourhood – Open sets – Closed sets – Compact sets – Perfect sets – the Cantor set – Connected sets.

Unit II

Limit of functions – Continuous functions – Continuity and Compactness – Continuity and Connectedness – Discontinuities – Monotonic functions.

Unit III

The derivative of a real function – Mean value theorems – The continuity of derivatives – L'Hospital's Rule – Derivative of higher order.

Unit IV

Definition and Existence of R-S Integral – Properties of the Integral – Integration and Differentiation.

Unit V

Discussion of main problem – Uniform Convergence – Uniform Convergence and Continuity – Uniform Convergence and Integration – Uniform Convergence and differentiation – The Stone Weierstrass theorem.

Text Book

Walter Rudin, Principles of Mathematical Analysis, McGraw – Hill Book Company, New York, 3rd Edition 1976.

Unit I - Chapter 2 § 2.15 - 2.47
Unit II - Chapter 4 § 4.1 - 4.30
Unit III - Chapter 5 § 5.1 - 5.15
Unit IV - Chapter 6 § 6.1 - 6.22
Unit V - Chapter 7 § 7.1 - 7.18 & 7.26

References

1. Tom Apostal, Mathematical Analysis, Addison – Wesley Publishing Company, London 1971.
2. Richard R.Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Company(Last reprint), 2017.
3. H.L.Roydan, Real Analysis, Pearson Education (Singapore) Pvt. Ltd. Third Edition, (Reprint) 2004.

Core Course II - Linear Algebra

Sem. I **Code : P14MA102**
Total Hrs.: 90 **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to understand the structure of vector spaces.
2. be able to comprehend matrices as linear transformations between vector spaces.
3. know direct sum decomposition of vector spaces.
4. be able to understand inner product spaces and their properties.

Learning outcome:

On completion of the course, the student will be able to analyse vector spaces and transformations defined on vector spaces.

Unit I

Fields - Systems of Linear Equations – Matrices and Elementary Row operations – Row-Reduced Echelon Matrices – Matrix Multiplication – Invertible Matrices – Vector spaces – Subspaces – Bases and Dimension – Coordinates.

Unit II

The Algebra of Linear Transformations – Isomorphism of Vector Spaces – Representation of Linear Transformations by Matrices – Linear Functionals – The Double Dual – The Transpose of a Linear Transformation.

Unit III

Algebras - The Algebra of Polynomials –Polynomial Ideals – The Prime Factorization of a Polynomial - Commutative rings – Determinant Functions.

Unit IV

Characteristic Values – Annihilating Polynomials - Invariant subspaces – Direct-sum Decompositions.

Unit V

Invariant Direct sums – The Primary Decomposition Theorem – Inner Products – Inner Product Spaces – Unitary Operators – Normal Operators.

Text Book

Kenneth Hoffman and Ray Kunze, Linear Algebra, Prentice – Hall of India Private Limited, New Delhi, 2nd Edition 2011.

Unit I Chapter 1 § 1.1 – 1.6 &Chapter 2 §2.1 – 2.4
Unit II Chapter 3 § 3.2 – 3.7
Unit III Chapter 4 § 4.1 – 4.2, 4.4 – 4.5 & Chapter 5 § 5.1 – 5.2
Unit IV Chapter 6 § 6.1 – 6.4, 6.6
Unit V Chapter 6 § 6.7 - 6.8 & Chapter 8 § 8.1 – 8.2, 8.4 – 8.5

References

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, New Delhi, 1975.
2. David C. Lay, Linear Algebra and its Applications, Pearson Education Pvt. Ltd. Third Edition (Fifth Indian Reprint) 2005
3. I. S. Luther and I.B.S. Passi, Algebra, Vol. I – Groups, Vol. II – Rings, Narosa Publishing House (Vol. I – 1996, Vol. II - 1999)
4. N. Jacobson, Basic Algebra, Vols. I & II, Freeman, 1980 (also published by Hindustan Publishing Company).

Core Course III - Ordinary Differential Equations

Sem. I **Code : P16MA103**
Total Hrs.: 90 **Credits : 4**

General objectives:

On completion of this course, the learner will

1. know different methods of solving ordinary differential equations.
2. be able to understand the existence of special functions and their properties.
3. be able to analyse the analytical properties of a solution of an initial value problem.
4. be able to analyse the stability and critical points of system of nonlinear equations.
5. know the applications of ordinary differential equations in physics.

Learning outcome:

On completion of the course, the student will be able to analyse the existence and behavior of solution of an initial value problem and a system of non-linear equations.

Unit I

The general solution of the homogeneous equation – The use of one known solution to find another – The method of variation of parameters – Power Series solutions. A review of power series – Series solutions of first order equations – Second order linear equations ; Ordinary points.

Unit II

Regular Singular Points – Gauss's hypergeometric equation – The Point at infinity – Legendre Polynomials – Bessel functions – Properties of Legendre Polynomials and Bessel functions.

Unit III

Linear Systems of First Order Equations – Homogeneous equations with constant coefficients – The Existence and uniqueness of solutions of Initial Value Problems for First Order Ordinary Differential Equations – The method of solutions of successive approximations and Picard's theorem.

Unit IV

Oscillation theory and Boundary Value Problems – Qualitative properties of solutions – Oscillations and the Sturm separation theorem, Sturm Comparison Theorems – Eigenvalues, Eigen functions and the Vibrating String.

Unit V

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.

Text Book

George F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill Publishing Company Limited, New Delhi, Second Edition 2003.

Unit I Chapter 3 § 14,15,16,19 & Chapter 5 § 26,27,28
Unit II Chapter 5 § 29,30,31,32 & Chapter 8 § 44,45,46,47
Unit III Chapter 10 § 55,56 & Chapter 13 § 68,69
Unit IV Chapter 4 § 24,25 & Chapter 7 § 40
Unit V Chapter 11 § 58,59,60,61,62

References

1. W.T. Reid, Ordinary Differential Equations, John Wiley & Sons, New York, 1971.
2. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw Hill Publishing Company, New York, 1955.

Core Course IV - Calculus of Variations, Integral Equations and Transforms

Sem. I **Code : P16MA104**
Total Hrs.: 90 **Credits : 4**

General objectives:

On completion of this course, the learner will

1. know functionals and the construction of Euler's equation.
2. be able to understand variational methods for solving differential equations.
3. be able to analyse variational problems with moving boundaries.
4. know different integral equations and methods of solving them.
5. be able to understand Green's function in reducing boundary value problems to integral equations.
6. know methods of finding infinite and finite Fourier transforms and Fourier integrals.

Learning outcomes:

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

1. solve boundary value problems through integral equations using Green's function.
2. find extreme values of functionals.

Unit I

The Calculus of Variations - Functionals – Euler's equations – Geodesics – Variational problems involving several unknown functions.

Unit II

Functionals dependent on higher order derivatives – Variational problems involving several independent variables – Constraints and Lagrange multipliers.

Unit III

Isoperimetric problems – The general variation of a functional – Variational problems with moving boundaries – Hamilton's principle, Sturm – Liouville's problems and variational methods – Rayleigh's principle – Ritz method.

Unit IV

Integral Equations – Introdution – Relation between differential and integral equations – Relationship between Linear differential equations and Volterra integral equations – The Green's function and its use in reducing boundary value problems to integral equations – Fredholm equations with separable kernels – Fredholm equations with symmetric kernels : Hilbert Schmidt theory – Iterative methods for the solution of integral equations of the second kind – The Neumann series – orthogonal kernels.

Unit V

Fourier transform - The infinite Fourier transform – The finite Fourier transform – Fourier integral theorem – Different forms of Fourier integral formula – Problems related to Fourier integral and finite Fourier transform.

Text Books

1. Dr. M.K. Venkataraman, Higher Mathematics for Engineering and Sciences, The National Publishing Company, 2001 (Unit I , II, III & IV).
2. J.K.Goyal and K. P. Gupta, Integral Transforms, K.K.Mittal for Pragati Prakashan, 7th Edition (1995 - 96), (Unit V).

Unit I	Chapter 9	§	1 – 11
Unit II	Chapter 9	§	12 – 14
Unit III	Chapter 9	§	15 – 21
Unit IV	Chapter 10	§	1 – 11
Unit V	Chapter 2	Part 1 & Part 2	

References

1. Krasnov, Kiselu and Marenko , Problems and Exercises in Integral Equations, MIR Publishers, 1971.
2. Francis. B. Hildebrand , Methods of Applied Mathematics, Prentice-Hall of India Pvt. Ltd., New Delhi, Second Edition 1968.
3. Ram. P. Kanwal, Linear Integral Equations - Theory and Techniques, Academic press, New York, 1971.

Elective Course I - Graph Theory

Sem. I | **Code : P14MA1:1**
Total Hrs.: 90 | **Credits : 4**

General objectives:

On completion of this course, the learner will

1. be able to understand basic concepts of graph theory.
2. know the applications of graphs in other disciplines.

Learning outcomes:

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

1. identify standard graphs and list their properties.
2. use standard graphs to model different networks and study the networks.

Unit I

Graphs and Simple Graphs – Graph Isomorphism – The Incidence and Adjacency Matrices – Subgraphs – Vertex, Degrees – Paths and Connections – Cycles. Trees – Cut edges and bonds, Cut vertices, Cayley's formula.

Unit II

Connectivity, Blocks, Euler Tours, Hamilton cycles.

Unit III

Edge Chromatic number, Vizing's Theorem, Independent Sets, Ramsey's Theorem – Turan's Theorem.

Unit IV

Chromatic number, Brook's theorem, Hajos conjucture, Chromatic Polynomials, Girth and Chromatic number, Plane and Planar Graphs, Dual Graphs – Euler's formula.

Unit V

The Five Colour Theorem and Four Colour Conjecture, Directed Graphs, Directed Paths – Directed Cycles.

Text Book

Bondy, J.A.& Murthy, U.S.R., Graph Theory with Applications, The Mac Millan Press Ltd., 1976.

Unit I Chapter 1 § 1.1 – 1.7 & Chapter 2 § 2.1 – 2.4
Unit II Chapter 3 § 3.1, 3.2 & Chapter 4 § 4.1 & 4.2
Unit III Chapter 6 § 6.1, 6.2 & Chapter 7 § 7.1 – 7.3
Unit IV Chapter 8 § 8.1 – 8.5 & Chapter 9 § 9.1 – 9.3
Unit V Chapter 9 § 9.6 & Chapter 10 § 10.1 – 10.3

References

1. Harary, Graph Theory, Narosha Publishing House, New Delhi, 1988.
2. Arumugam, S & Ramachandran, S., Invitation to Graph Theory, New Gamma Publishing House, Palayamkottai, 1993.

Core Course V - Algebra

Sem. II | **Code : P14MA205**
No. of hrs.: 90 | **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to understand the structure of finite abelian groups and their non-isomorphic copies.
2. be able to investigate the solvability of polynomials through Galois theory.

Learning outcomes:

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

1. analyse structure and properties of finite abelian groups, rings and modules.
2. construct finite extensions of fields.
3. investigate the resolving field of polynomilas.
4. investigate solvability of polynomials through Galois theory.

Unit I

Another counting principle – Conjugacy – Class equation and its applications – Cauchy's theorem – Partition of a positive integer 'n' – Relation between conjugate classes in S_n and number of partitions of 'n' - Sylow's theorem – Proof (First and Third proofs are omitted) and applications.

Unit II

Direct products – Internal direct products, external direct products and the relation between them - Finite abelian groups – Modules

Unit III

Extension fields- Roots of polynomials – More about roots

Unit IV

Galois theory – Fixed fields - Normal extensions - Galois group of a polynomial – Fundamental theorem of Galois theory

Unit V

Solvability by radicals – Galois Groups over the rationals

Text Book

I. N. Herstein, Topics in Algebra, Wiley – Eastern Ltd., New Delhi, 1975.

Unit I Chapter 2 § 2.11, 2.12 (Excluding the first proof &Lemmas 2.12.1,2.12.2 and 2.12.5)
Unit II Chapter 2 § 2.13, 2.14, Chapter 4 § 4.5
Unit III Chapter 5 § 5.1, 5.3, 5.5
Unit IV Chapter 5 § 5.6
Unit V Chapter 5 § 5.7, 5.8

References

1. P. M. Cohn, Algebra (Vols. – I, II, III), John Wiley & Sons, 1982, 1989, 1991.
2. N. Jacobson, W. H. Freeman, Basic Algebra (Vols. – I & II), 1980 (also published by Hindustan Publishing Company)
3. D. S. Malik, J. N. Mordeson and M. K. Sen, Fundamentals of Abstract Algebra, McGraw Hill International Edition, 1997.

Core Course VI - Partial Differential Equations

Sem. II **Code : P14MA206**
No. of hrs.: 90 **Credits : 4**

General objectives:

On completion of this course, the learner will

1. be able to analyse the origin of partial differential equations and their solutions.
2. be able to understand different methods of solving various first order and second order partial differential equations.
3. know the applications of second order and higher order partial differential equations in physics.

Learning outcome:

On completion of the course, the student will be able to classify and solve first and second order partial differential equations.

Unit I

Partial differential equations- origins of first order Partial differential equations- Cauchy's problem for first order equations- Linear equations of the first order- Integral surfaces Passing through a Given curve-surfaces Orthogonal to a given system of surfaces -Non linear Partial differential equations of the first order.

Unit II

Cauchy's method of characteristics- compatible systems of first order equations- Charpits method- Special types of first order equations- Solutions satisfying given conditions- Jacobi's method.

Unit III

Partial differential equations of the second order: The origin of second order equations- second order equations in Physics – Higher order equations in Physics - Linear partial differential equations with constant co- efficient- Equations with variable co-efficients- Characteristic curves of second order equations

Unit IV

Characteristics of equations in three variables- The solution of Linear Hyperbolic equations- Separation of variables. The method of Integral Transforms – Non Linear equations of the second order.

Unit V

Laplace equation : Elementary solutions of Laplace's equations-Families of equipotential Surfaces-Boundary value problems-Separation of variables –Problems with Axial Symmetry.

Text Book:

Ian N. Sneddon, Elements of Partial Differential Equations, Dover Publication –INC, New York, 2006.

Unit I	Chapter II	Sections	1 to 7
Unit II	Chapter II	Sections	8 to 13
Unit III	Chapter III	Sections	1 to 6
Unit IV	Chapter III	Sections	7 to 11
Unit V	Chapter IV	Sections	2 to 6

References

1. M.D.Raisinghania, Ordinary and Partial Differential Equations, S.Chand & co., 2005.
2. E.T.Copson, Partial Differential Equations, Cambridge University Press (2 October 1975).

Core Course VII - Fluid Dynamics

Sem. II **Code : P16MA207**
Total Hrs. : 90 **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to understand the kinematics of a fluid through equations of motion of the fluid.
2. be able to analyse some two dimensional and three dimensional flows.
3. be able to understand Navier-Stokes equations of motion of a viscous fluid and some solvable problems in viscous flow.
4. be able to understand the importance of complex analysis in the analysis of flow of fluids.

Learning outcome:

On completion of the course, the student will be able to analyse the technical characteristics like pressure, velocity, viscosity of two dimensional and three dimensional flows and their media.

Unit I

Real fluids and Ideal Fluids – Velocity of a fluid at a point – Streamlines and Pathlines : Steady and Unsteady Flows – The Velocity potential – The Vorticity vector – Local and particle rates of change – The equation of Continuity – worked examples – Acceleration of a fluid .

Unit II

Pressure at a point in a fluid at rest – Pressure at a point in a moving fluid – Euler's equations of motion – Bernoulli's equation – Discussion of the case of Steady Motion under Conservative Body forces – Some potential theorems – Impulsive motion.

Unit III

Sources, sinks and doublets – Images in a rigid infinite plane – Images in Solid spheres – Axisymmetric flows; Stoke's Stream function.

Unit IV

The stream function – The complex potential for two dimensional, irrotational, incompressible flow – Complex velocity potentials for standard two dimensional flows – Some worked examples – Two dimensional image systems – The Milne Thomson circle theorem .

Unit V

Stress Components in a Real Fluid – Relations between Cartesian components of stress - Translational Motion of Fluid element – The Coefficient of Viscosity and Laminar Flow – The Navier-Stokes equations of Motion of a Viscous Fluid, Some solvable problems in Viscous flow.

Text Book

Chorlton.F, Text Book of Fluid Dynamics, CBS Publishers & Distributors, Delhi, 2004.

Unit I Chapter 2 § 2.1 – 2.9
Unit II Chapter 3 § 3.1, 3.2, 3.4 – 3.8, 3.11
Unit III Chapter 4 § 4.2 – 4.5
Unit IV Chapter 5 § 5.3 – 5.8.1, 5.8.2
Unit V Chapter 8 § 8.1 – 8.3, 8.8 – 8.10

References

1. H. Schlichting, Boundary Layer Theory, McGraw Hill Company, New York, 1979.
2. Rathy R.K, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi,1976.

Elective Course II - Object Oriented Programming in C ++

Sem. II | **Code : P16MA2:P**
Total Hrs. : 75 | **Credits : 4**

General objectives:

On completion of this course, the learner will

1. be able to understand the basic concepts of object oriented programming.
2. be able to analyse the differences between C and C++.
3. be able to apply the knowledge of C++ to design programmes for solving problems.

Learning outcome:

On completion of the course, the student will be able to develop codes in C++ to solve problems.

Unit I

An Overview of C++: What is Object Oriented Programming? – C++ Console I/O Commands – Classes– Some Difference Between C and C++ – Introduction Function Overloading – Introducing Classes : Constructor and Destructor Functions –Constructors that take Parameters – Introducing Inheritance –Object Pointers – In–Line Functions – Automatic In–Lining.

Unit II

A Closer Look at Classes: Assigning Objects – Passing Object to Functions – Returning Object from Functions – An Introduction to Friend Functions. Arrays, Pointers and References: Arrays of Object – Using Pointers to Objects – The this Pointer – Using new & delete – More –about new & delete – Reference – Passing reference to the Objects – Returning reference – Independent References and Restrictions.

Unit III

Function Overloading: Overloading Constructor Functions – Creating and Using a Copy Constructor – Using Default Arguments – Overloading and Ambiguity – Finding the Address of an Overloaded Function. Introducing Operator Overloading: The Basics of Operator Overloading – Overloading Binary Operators – Overloading the Relational and Logical Operators – Overloading a Unary Operator – Using Friend Operator Functions – A closer look at the Assignment Operator Overloading– The Subscript [] Operator Overloading.

Unit IV

Inheritance: Base Class Access Control – Using Protected Members – Constructors, Destructors and Inheritance – Multiple Inheritance – Virtual Base Classes. Introducing the C++ I/O System: Some C++ I/O Basics – Formatted I/O using width ( ), precision( ), fill( ) – Using I/O Manipulators – Creating your own Inserters – Creating Extractors.

Unit V

Advanced C++ I/O: Creating your own Manipulators –File I/O Basics –Unformatted, Binary I/O – More Unformatted I/O Functions – Random Access – Checking the I/O Status – Customized I/O and Files. Virtual Functions: Pointers and Derived Classes – Introduction to Virtual Functions – More about Virtual Functions – Applying Polymorphism – Templates and Exception Handling: Exception Handling – Handling Exceptions Thrown.

List of Exercises:

1. Class and objects
2. Functions
    a) Friend functions
    b) Inline functions
3. Constructor and Destructor
    a) Copy constructor
    b) Constructor Overloading
4. Inheritance Types
5. Polymorphism
    a) Function overloading
    b) Operator overloading (unary and binary)
    c) Virtual functions
6. I/O Formatting and I/O Manipulators
7. Files (Read, Write and update)

Text Book

Herbert Schildt, Teach Yourself C++,McGraw Hill, Third Edition, 2000.

References

1. Robert Lafore, Object Oriented Programming in Turbo C++, Galgotia Publications, 2001.
2. E. Balaguruswamy, Object – Oriented Programming with C++, Tata McGraw Hill Publishing Company Limited, 1999.

Elective Course III – Fuzzy Set Theory and its Applications

Sem. II **Code : P19MA2:1**
Total Hrs. : 75 **Credits : 4**

General Objectives :

On completion of this course, the learner will

1. be able to understand the basic mathematical elements of the theory of fuzzy sets.
2. know the application of fuzzy set theory combined with different areas.

Learning outcomes:

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

1. identify fuzzy sets and perform set operations on fuzzy sets.
2. apply fuzzy logic in various real life situations such as decision making and inventory control.

Unit – I

Fuzzy Sets : Definition of Fuzzy set- Expanding concepts of fuzzy sets.

Operation of Fuzzy Sets : Standard operation of fuzzy sets -Fuzzy Complement - Fuzzy Union – Fuzzy Intersection – t- norms and t- conforms.

Unit –II

Fuzzy Relation and Composition: Fuzzy Relation – Extension of fuzzy set.

Fuzzy Graph and Relation : Fuzzy graph – Characteristics of fuzzy relation – Classification of fuzzy relation

Unit – III

Fuzzy Number: Concept of fuzzy number – Operation of fuzzy number – Triangular fuzzy number – other types of fuzzy number.

Unit – IV

Fuzzy Function: Kinds of fuzzy function – fuzzy extrema of function – Integration and Differentiation of fuzzy function.

Unit – V

Fuzzy logic : Fuzzy logic –Linguistic variable –fuzzy truth qualifier – Representation of fuzzy rule.

Text Book :

Kwang H. Lee, First course on Fuzzy Theory and Applications, Springer- Verlag Berlin Heidelberg,2005.

Unit I – Chapter 1 : Sections – 1.4, - 1.6 , Chapter 2 : Sections – 2.1-2.4,2.6
Unit II – Chapter 3 : Sections – 3.3,3.4,   Chapter 4 : Sections – 4.1- 4.3
Unit III – Chapter 5 : Sections – 5.1-5.4
Unit IV – Chapter 6 : Sections – 6.1-6.3
Unit V – Chapter 8 : Sections – 8.2-8.5

References :

1. Sudhir K. Pundir Rimple Pundir, Fuzzy Set Theory and their Applications, Pragati Prakashan, 9th edition , 2018.
2. H.J. Zimmermann, Fuzzy Set Theory and its Applications,Kluwer Academic Publishers, 1975.
3. Klir G.J and Yuan Bo, Fuzzy sets and Fuzzy logic : Theory and Applications, Prentice hall of India, New Delhi, 2005.

Core Course VIII - Topology

Sem. III | **Code : P14MA308**
Total Hrs. : 90 | **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to understand the meaning of a topology, different topological spaces and continuous functions.
2. know the construction of complete metric spaces through topological spaces
3. be able to analyse the existence of certain real-valued continuous functions on a topological space.
4. be able to comprehend a topological space as a generalisation of the real metric space.

Learning outcome:

On completion of the course, the student will be able to analyse various topological spaces and the properties of functions defined on these spaces.

Unit I

Topological spaces – Basis for a topology – The order topology – The product topology on X x Y – The subspace topology – Closed sets and limit points – Continuous functions – The product topology – The metric topology.

Unit II

The metric topology continued – Connected spaces – Connected subspaces of the real line – Components and local connectedness.

Unit III

Compact spaces – Compact subspaces of the real line – Limit point compactness – The countability axioms.

Unit IV

The separation axioms – Normal spaces –The Uryshon Lemma – Completely regular spaces.

Unit V

The Uryshonmetrization theorem – Complete metric spaces – Compactness in metric spaces.

Text Book

James. R. Munkres, Topology, Pearson Education Singapore Pvt. Ltd. Second Edition, (Ninth Indian Reprint), 2005.

Unit I	Chapter 2	§ 12 - 20	
Unit II	Chapter 2	§ 21	&Chapter 3 § 23 - 25
Unit III	Chapter 3	§ 26 – 28	& Chapter 4 § 30
Unit IV	Chapter 4	§ 31 - 33	
Unit V	Chapter 4	§ 34	& Chapter 7 § 43 & 45

References

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Company, 1963.
2. James Dugundji, Topology, Prentice Hall of India Private Limited, 1975.

Core Course IX - Measure and Integration

Sem. III | **Code : P14MA309**
Total Hrs. : 90 | **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to understand the concept of measurable sets, measurable functions and the integration of such functions on the real line.
2. know abstract measure spaces and the extension of a measure.
3. be able to understand and to analyse the notion of convergence in measure and signed measures.
4. be able to understand the construction and the properties of measures in a product space and the integration with respect to a product measure.

Learning outcomes:

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

1. identify measurable sets and measurable functions.
2. identify Integrable functions and evaluate Lebesgue integrals.

Unit I

Measure on Real line – Lebesgue outer measure – Measurable sets – Regularity – Measurable function - Borel and Lebesgue measurability.

Unit II

Integration of non-negative functions – The General integral – Integration of series – Riemann and Lebesgue integrals.

Unit III

Abstract Measure spaces – Measures and outer measures – Completion of a measure – Measure spaces – Integration with respect to a measure.

Unit IV

Convergence in Measure – Almost uniform convergence – Signed Measures and Halin Decomposition – The Jordan Decomposition.

Unit V

Measurability in a Product space – The Product Measure and Fubini's Theorem.

Text Book

G. De Barra, Measure Theory & Integration, New Age International Pvt. Ltd.,2003.

Unit I Chapter 2 § 2.1 – 2.5
Unit II Chapter 3 § 3.1 – 3.4
Unit III Chapter 5 § 5.1 – 5.6
Unit IV Chapter 7 § 7.1, 7.2 & Chapter 8 § 8.1 & 8.2
Unit V Chapter 10 § 10.1 & 10.2

References

1. M.E. Munroe, Measure and Integration, Addison – Wesley Publishing Company, Second Edition 1971.
2. P.K.Jain, V.P.Gupta, Lebesgue Measure and Integration, New Age International Pvt. Ltd. Publishers, New Delhi, 1986 (Reprint 2000).
3. Richard L. Wheeden and AntoniZygmund, Measure and Integral : An Introduction to Real Analysis, Marcel Dekker Inc. 1977.
4. Inder, K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, New Delhi, 1997.

Core Course X – Complex Analysis

Sem. III **Code : P14MA310**
Total Hrs. : 90 **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to comprehend the local and global properties of analytic functions.
2. know and understand harmonic functions and their basic properties.
3. be able to understand properties of entire functions.

Learning outcomes:

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

1. evaluate radius of convergence of a given power series.
2. identify and Analyse properties of analytic functions, meromorphic functions.
3. evaluate definite complex integrals

Unit I

Power series – Abel's limit theorem – Cauchy's theorem for a rectangle.

Unit II

Higher derivatives – Morera's theorem – Liouville's theorem – Cauchy's estimates – Fundamental theorem of algebra – Local properties of analytical functions – Removable singularities – Taylor's theorem – Zeros and poles – Meromorphic functions – Essential singularities.

Unit III

The general form of Cauchy's theorem – Chains and cycles - Simply connected sets – Homology – The general statement of Cauchy's theorem and its proof – Locally exact differentials – Multiply connected regions – The residue theorem – The Argument principle – Evaluation of definite integrals.

Unit IV

Harmonic functions – Basic properties – Polar form – Mean value property – Poisson's formula – Schwartz's theorem – Reflection principle.

Unit V

Partial fractions – Infinite products – Canonical products – Entire functions – Representation of entire functions – Formula for sin z and gamma functions – Jensen's formula.

Text Book

L.V.Ahlfors, Complex Analysis, McGraw Hill International, Third Edition, 1979.

Unit I Chapter 2 § 2.4, 2.5 & Chapter 4 § 1.4
Unit II Chapter 4 § 2.3, 3.1 & 3.2
Unit III Chapter 4 § 4.1 - 4.7, 5.1 - 5.3
Unit IV Chapter 4 § 6.1 - 6.5
Unit V Chapter 5 § 2.1 - 2.4 & 3.1

References

1. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.
2. Churchill, R.V. Brown J. W., Complex Variables and Application, McGraw Hill Publishing Pvt. Ltd., 4th edition, 1984.
3. S. Lang, Complex Analysis, Addison Wesley, 1977

Core Course XI - Probability & Statistics

Sem. III **Code : P16MA311**
Total Hrs. : 90 **Credits : 4**

General objective:

On completion of this course, the learner will

1. know probability and to understand probability as a continuous set function.
2. be able to understand the notion of a random variable and to know discrete and continuous random variables, their probability functions, distribution functions and expectations.
3. be able to analyse the construction of moment generating functions and to understand different results on random variables.

Learning outcomes:

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

1. calculate the probability for any event and use it to estimate certain possibilities.
2. identify the distributions depending on the nature of the data and derive inferences.

Unit I

Basic concepts – Sample space and events – Axioms of probability – Some simple propositions – equally likely outcomes – Probability as a continuous set function - Probability as a measure of belief.

Unit II

Conditional probabilities – Baye's formula – Independent events – P(./F) is a probability – random variables – Expectation of a function of a random variable – Bernoulli, Binomial and Poisson random variables.

Unit III

Discrete probability distributions – Geometric, Negative Binomial and Hypergeometric random variables – the zeta (z;pf) distribution – continuous random variables – the uniform and normal random variables – exponential random variables – other continuous distributions – the distribution of a function of a random variable.

Unit IV

Joint Distribution functions – Independent random variables – Their sums – conditional distribution – Joint probability distribution of functions – expectation – variance – covariance – conditional expectation and prediction.

Unit V

Moment generating function – general definition of expectation – limit theorems – Chebyshev's inequality – weak law of large numbers – central limit theorems – the strong law of large numbers – other inequalities

Text Book

Sheldon Ross , A First Course in Probability, Maxwell MacMmillar International Edition, Maxmillar, New York, 6th Edition, 2008.

Unit I Chapter 2
Unit II Chapter 3 & Chapter 4 § 4.1 – 4.7
Unit III Chapter 4 § 4.8 & Chapter 5
Unit IV Chapter 6 § 6.1 – 6.5 &Chapter 7 § 7.1 – 7.5
Unit V Chapter 7 § 7.6 – 7.8 & Chapter 8 § 8.1 – 8.5

Reference

Geoffery Grimmell and Domenic Welsh , Probability – An Introduction, Oxford University Press, 1986.

Elective Course IV : Data Structures and Algorithms

Sem. III **Code : P19MA3:1**
Total Hrs. : 90 **Credits : 4**

General Objectives

1. To understand the linear and nonlinear data structures
2. To learn sorting and searching techniques of data structure.
3. To learn to develop various algorithms.

Unit – I

Introduction and Overview: Definitions – Concept of Data Structures – Overview of Data Structures – Implementation of Data Structures. Linked Lists: Definition – Single Linked List – Circular Linked List – Double Linked List – Circular Double Linked List – Application of Linked Lists. Stacks: Introduction – Definition – Representation of Stack – Operations on Stacks – Application of Stacks. Queues: Introduction – Definition – Representation of Queues – Various Queue Structures– Application of Queues.

Unit – II

Trees : Basic Terminologies – Definition and Concepts – Representation of Binary Tree – Operations on Binary Tree – Types of Binary Trees – Trees and Forests – B Trees .

Unit – III

Graphs: Introduction – Graph Terminologies – Representation of Graphs – Operations on Graphs – Applications of Graph Structures – BDD and its Applications. Introduction: What is an Algorithm? – Algorithm Specification – Performance Analysis.

Unit – IV

Divide–and–Conquer: General Method – Binary Search – Finding the Maximum and Minimum – Merge Sort –Quick Sort – Selection. The Greedy Method: The General Method –Minimum Cost Spanning Trees – Single–Source Shortest Paths.

Unit – V

Dynamic Programming: The General Method – Multistage Graphs – All Pairs Shortest Paths – Single Source Shortest Paths. Backtracking: The General Method – The 8-Queens Problem – Sum of Subsets – Graph Coloring.

Text Books

1. Samanta D, Classic Data Structures, Prentice Hall of India, 2006.
2. Ellis Horowitz, SartajSahni and Sanguthevar Rajasekaran, Fundamentals of Computer Algorithms, Galgotia Publications, Second Edition, 1998.

Unit I Chapter 1 § 1.1 – 1.4

Chapter 3 § 3.1 – 3.6

Chapter 4 § 4.1 – 4.5

Chapter 5 § 5.1 – 5.5

Unit II Chapter 7 § 7.1 – 7.7

Unit III Chapter 8 § 8.1 – 8.6 & Chapter 1 § 1.1 – 1.3

Unit IV Chapter 3 § 3.1, 3.3 – 3.7 & Chapter 4 § 4.1, 4.6, 4.9

Unit V Chapter 5 § 5.1 – 5.4 & Chapter 7 § 7.1 – 7.4

Reference Books

1. V. Aho, J. E. Hopcroft, and J. D. Ullman, Data Structures and Algorithms, Pearson Education, 2008.
2. AnanyLevitin, Introduction to the Design and Analysis of Algorithms, Pearson Education 2003.

Elective Course - IV – Programming with JAVA

Sem. III **Code : P19MA3:2**
Total hrs. : 90 **Credits : 4**

General objective:

On completion of this course, the learner will be able to know programming with JAVA

Learning outcome:

On completion of this course, the learner will be able to write simple programs using JAVA

Unit I

Fundamentals of Object Oriented Programming: Introduction – Object Oriented Paradigm – Basic Concepts of OOP – Benefits of OOP – Applications of OOP.
Java Evolution: Java History – Java Features – Java and Internet – World Wide Web – Web Browsers – H/W and S/W requirements – Java Support Systems – Java Environment.
Overview of Java language: Introduction – Simple Java Program – Comments – Java Program Structure – Tokens – Java Statements – JVM – Command Line Arguments, Programming style.

Unit II

Constants – Variables – Data Types - Declaration of variables - Giving values to variables – Scope of variables – symbolic constants – Type Casting – Getting values of variables – Standard default values.
Operators and Expressions: Arithmetic Operators – Relational, Logical, Assignment, Increment and Decrement, Conditional Operator – Arithmetic Expressions, Evaluation of Expression – Precedence of Arithmetic Operators – Type Conversions – Operator Precedence and associativity – Mathematical Functions.

Unit III

Decision Making and Branching: Decision making with if statement – Simple if statement - The If… Else statement – Nesting of If… Else statements – The Else If Ladder –The Switch statement.
Decision Making and Looping: While statement – do statement – for statement – Jumps in Loops.

Unit IV

Classes, Objects and Methods: Defining a Class – Fields Declaration - Methods Declaration – Creating objects – Accessing Class Members– Constructors – Methods overloading – Static Members – Nesting of Methods – Inheritance – Overriding Methods – Final Variables and methods – Final classes – Finalizer methods – Abstract Methods and Classes – Methods with Varargs – Visibility Control.
Arrays, Strings and Vectors: Arrays – One Dimensional Arrays–Creating an array – Two Dimensional Arrays – Strings – Vectors.

Unit V

Interfaces: Multiple Inheritance: Defining Interfaces – Extending Interfaces – Implementing Interfaces.
Packages: Java API Packages – Using system packages – Naming conventions – Creating Packages – Accessing a Package – Using a Package –Adding a Class to a Package.

Text Book:

"Programming with JAVA", Fifth Edition 2018", E. Balagurusamy, TATA McGraw-Hill Publishing Company Limited, New Delhi

UNIT I	Chapters	: 1, 2, 3.1 - 3.7, 3.10 - 3.12
UNIT II	Chapters	: 4, 5.1 – 5.7, 5.10 - 5.15
UNIT III	Chapters	: 6.1 – 6.7, 7.1 – 7.5
UNIT IV	Chapters	: 8, 9.1 – 9.6
UNIT V	Chapters	: 10.1 – 10.4, 11.1 -11.8

Reference:

"Java – The Complete Reference", Seventh Edition, Herbert Schildt, McGraw Hill Publishing Company Limited.

Elective Course IV - Differential Geometry

Sem. III **Code : P19MA3:3**
Total Hrs. : 90 **Credits : 4**

General Objectives:

On completion of this course, the learner will

1. know the difference between plane curves and space curves.
2. be able to understand the aspects of geometry, cantered on the notion of curvature.
3. be able to apply the techniques of differential calculus in the field of geometry.

Learning outcomes:

On completion of the course, the student will

1. have the geometrical ideas over the surfaces, the normals and tangents, curvature and related equations of evolutes and involutes.
2. be able to understand the physical systems involved in partial differential equations.

Unit I

Curves in Space: Space curve - Tangent and Tangent line - Order of contact - Arc length Osculating plane - Normal plane - Rectifying plane - Fundamental planes - Curvature – Torsion Frenet Serret formulae.

Unit II

Intrinsic equations: Existence theorem and Uniqueness theorem - Helices - Osculating circle - Osculating sphere - Spherical indicatrices - Involutes and evolutes - Tangent surface.

Unit III

Curves and Surfaces: Definition of a surface - Regular point and singularities - Parametric transformations - Curves on a surface - Normal - General surface of revolution - Metric - First and second fundamental forms - Angle between the parametric curves.

Unit IV

Normal curvature - Meusnier's theorem - Principal directions - Lines of curvature - Rodrigue's formula - Euler's formula - Envelope of surfaces - Edge of Regression - Developable surfaces.

Unit V

Surface Theory: Gauss equation - Weingarten equations - Gauss characteristic equation - Mainardi-Codazzi equations – Geodesics.

Text Book:

Kailash Sinha, An Introduction to Differential Geometry, 4th Edition, Shalini Prakashan Publications, 1977.

Unit I: Chapter II: Sections 2.2, 2.3, 2.5 – 2.11, 2.13 – 2.20

Unit II: Chapter II: Section 2.22 - 2.26, 2.28 - 2.33

Unit III: Chapter III: Section 3.1 – 3.11, 3.14 - 3.16

Unit IV: Chapter IV: Section 4.1 - 4.4 – 4.10, 4.13 – 4.17

Unit V: Chapter V: Section 5.2 – 5.5, 5.14 – 5.16

References:

1. Struik, D.J., Lectures on classical Differential Geometry, 2nd Edition,Addison-Wesley, 1988.

2. Willmore, T.J., An Introduction to Differential Geometry, Oxford Univ. Press, 1964.

3. Somasundaram D., Differential geometry: A first course, Narosa, 2008.

Core Course XII - Functional Analysis

Sem. IV | **Code : P14MA412**
Total Hrs. : 90 | **Credits : 5**

General objectives:

On completion of this course, the learner will

1. be able to understand different algebraic structures of operators.
2. be able to comprehend the importance of theory of operators in solving initial value problems, boundary value problems and integral equations.
3. know spectral theory and the importance of its establishment.

Learning outcomes:

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

1. analyse various properties of Banach & Hilbert spaces.
2. analyse properties of operators defined on these spaces.
3. construct Banach algebras through Banach spaces.

Unit I

Banach Spaces : The definition and some examples – Continuous linear transformations – The Hahn-Banach theorem – The natural imbedding of N in N^{**} - The open mapping theorem – The conjugate of an operator.

Unit II

Hilbert Spaces : The definition and some simple properties – Orthogonal complements – Orthonormal sets – The conjugate space H^* - The adjoint of an operator – Self-adjoint operators – Normal and unitary operators – Projections.

Unit III

Finite-Dimensional Spectral Theory : Matrices – Determinants and the spectrum of an operator – The spectral theorem – A survey of the situation.

Unit IV

General Preliminaries on Banach Algebras : The definition and some examples – Regular and singular elements – Topological divisors of zero – The spectrum – The formula for the spectral radius – The radical and semi-simplicity.

Unit V

The Structure of Commutative Banach Algebras : The Gelfand mapping – Applications of the formula $r(x) = \lim||x^n||^{1/n}$ – Involutions in Banach Algebras – The Gelfand-Neumark theorem.

Text Book

G.F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill Publishing Company Ltd.,2006.

Unit I Chapter 9
Unit II Chapter 10
Unit III Chapter 11
Unit IV Chapter 12
Unit V Chapter 13

References

1. B.V. Limaye, Functional Analysis, Wiley Eastern Limited, Bombay, 2nd Print, 1985.
2. Walter Rudin, Functional Analysis, Tata McGraw Hill Publishing co., New Delhi, 1977.
3. K. Yosida, Functional Analysis, Springer-Verlag, 1974.
4. Laurent Schwarz, Functional Analysis, Courent Institute of Mathematical Sciences, New York University, 1964.

Core Course XIII - Numerical Analysis

Sem. IV **Code : P14MA413**
Total Hrs. : 90 **Credits : 4**

General objectives:

On completion of this course, the learner will

1. be able to analyse the rate of convergence and error in the construction of numerical techniques for solving linear algebraic equations.
2. be able to understand the designing of interpolating polynomials for finding approximate values of a function at some unknown points.
3. know different numerical methods for solving differential and integral equations.
4. be able to analyse the optimum choice of step length and the stability properties of some numerical methods.

Learning outcomes:

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

1. derive the rate of convergence and estimate the error in a constructed numerical technique.
2. construct interpolating polynomials.

Unit I

Transcendental and polynomial equations: Rate of convergence – Secant Method, Regula Falsi Method, Newton Raphson Method, Muller Method and Chebyshev Method. Polynomial equations: Descartes' Rule of Signs - Iterative Methods: Birge-Vieta method, Bairstow's method Direct Method: Graeffe's root squaring method.

Unit II

System of Linear Algebraic equations and Eigen Value Problems: Error Analysis of Direct methods – Operational count of Gauss elimination, Vector norm, Matrix norm, Error Estimate. Iteration methods- Jacobi iteration method, Gauss Seidel Iteration method, Successive Over Relaxation method- Convergence analysis of iterative methods, Optimal Relaxation parameter for the SOR method. Finding eigen values and eigen vectors – Jacobi method for symmetric matrices and Power methods only.

Unit III

Interpolation and Approximation:-Hermite Interpolations, Piecewise and Spline Interpolation – piecewise linear interpolation, piecewise quadratic interpolation, piecewise cubic interpolation, spline interpolation-cubic Spline interpolation. Bivariate Interpolation- Lagrange Bivariate interpolation. Least square approximation.

Unit IV

Differentiation and Integration: Numerical Differentiation – Optimum choice of Step length – Extrapolation methods – Partial Differentiation. Numerical Integration: Methods based on undetermined coefficients - Gauss Legendre Integration method andLobatto Integration Methods only.

Unit V

Ordinary differential equations – Single step Methods: Local truncation error or Discretization Error, Order of a method, Taylor Series method, Runge-Kutta methods: Explicit Runge–Kutta methods–Minimization of Local Truncation Error, System of Equations, Implicit Runge-Kutta methods. Stability analysis of single step methods (RK methods only).

Text Book

M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International (p) Limited Publishers, New Delhi, Sixth Edition 2012.

Unit I Chapter 2 § 2.5 (Pages 41-52), 2.9 (Pages 83-99)
Unit II Chapter 3 § 3.3(Pages 134-140), 3.4(Pages 146-164), 3.5(Pages 170-173), 3.7 (Pages179-185) and 3.11 (Pages 196-198)
Unit III Chapter 4 § 4.5 - 4.7 & 4.9 (Pages 284-290)
Unit IV Chapter 5 § 5.2 - 5.5(Pages 320-345) and 5.8(pages 361 – 365 and 380-386)
Unit V Chapter 6 § 6.4(Pages 434-459) and 6.5(Pages 468-475)

References

1. Kendall E. Atkinson, An Introduction to Numerical Analysis, II Edn., John Wiley & Sons, 1988.
2. M.K. Jain, Numerical Solution of Differential Equations, II Edn., New Age International Pvt Ltd., 1983.
3. Samuel. D. Conte, Carl. De Boor, Elementary Numerical Analysis, McGraw-Hill International Edn., 1983.

Core Course XIV - Operations Research

Sem. IV | **Code : P14MA414**
Total Hrs. : 90 | **Credits : 4**

General objectives:

On completion of this course, the learner will

1. know methods of solving Integer Programming problems and Multistage programming.
2. know methods of using Operations Research techniques in decision making
3. be able to understand non-linear programming algorithms.

Learning outcomes:

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

1. solve Integer Programming problems.
2. construct operational research models to solve problems in decision making.

Unit I

Integer Programming.

Unit II

Dynamic (Multistage) programming.

Unit III

Decision Theory and Games.

Unit IV

Inventory Models.

Unit V

Non-linear Programming algorithms.

Text Book

Hamdy A. Taha, Operations Research, Macmillan Publishing Company, 4th Edition, 1987.

Unit I Chapter 8 § 8.1 – 8.5
Unit II Chapter 9 § 9.1 – 9.5
Unit III Chapter 11 § 11.1 – 11.4
Unit IV Chapter 13 § 13.1 – 13.4
Unit V Chapter 19 § 19.1, 19.2

References

1. O.L. Mangasarian, Non Linear Programming, McGraw Hill, New York, 1969 .
2. Mokther S. Bazaraa and C.M. Shetty, Non Linear Programming, Theory and Algorithms,Willy, New York, 1979.
3. Prem Kumar Gupta and D.S. Hira, Operations Research - An Introduction, S. Chand and Co., Ltd., New Delhi, 2012.
4. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Limited, New Delhi,1979.

Elective Course V - Stochastic Processes

Sem. IV | **Code : P14MA4: 1**
Total Hrs. : 90 | **Credits : 4**

General objectives:

On completion of this course, the learner will

1. be able to understand various elements of Stochastic Processes.
2. be able to understand renewal processes and their applications.
3. be able to understand queuing processes and know methods of deriving the programme measures of queuing models.

Learning outcomes:

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

1. identify and classify various stochastic processes.
2. construct queueing models and derive programme measures of a queueing model.

Unit I

Elements of Stochastic Processes - Two simple examples of stochastic processes - Classification of general stochastic processes - Defining a discrete time Markov chain - Classification of states of a Markov chain - Recurrence- (Abel's Lemma-Statement only) Examples of recurrent Markov chains-More on recurrence.

Unit II

Basic limit theorem of Markov chains and applications-Discrete renewal equation-Absorption probabilities-Criteria for recurrence.

Unit III

Classical examples of continuous time Markov Chains-General pure birth processes and Poisson processes-Birth and Death processes-Differential equations of birth and death processes- Linear growth process with immigration-Birth and death processes with absorbing states- Finite state continuous time Markov chain.

Unit IV

Definition of a renewal processes and related concepts- Some examples of renewal processes- More on some special renewal processes - Renewal equations and the Elementary renewal theorem- Basic renewal theorem-Applications of the renewal theorem.

Unit V

Queueing processes-General description – The simple queuing processes (M/M/1) – Embedded Markov chain method applied to the Queueing model (M/GI/1) – Exponential service times (GI/M/1) – The virtual Waiting time and the busy period.

Text Books:

1. Samuel Karlin & Howard M.Taylor, A First Course in Stochastic Processes, Academic press, 1975. (For units I to IV)
2. Samuel Karlin & Howard M.Taylor, A Second Course in Stochastic Processes, Academic press, 1981 (For unit V)

.

Unit I Chapter 1 § 2, 3 & Chapter 2 § 1, 2, 3, 4, 5, 6, 7
Unit II Chapter 3 § 1, 3, 4
Unit III Chapter 4 § 1, 2, 4, 5, 6 (Examples 1 only), 7, 8
Unit IV Chapter 5 § 1, 2 (Examples a, c, d, f and g only), 3 (Examples A&B), 4, 5, 6
Unit V Chapter 18 § 1, 2, 4, 5, 8.

References

1. J.Medhi, Stochastic Processes, Wiley Eastern Limited 3rd Edition, 2009.
2. U.Narayanan Bhat, Elements of Applied Stochastic Processes, John Wiley & Sons, 1984.
3. S.K. Srinivasan & K.M. Mehata, Probability and Random Process, Tata McGraw Hill, New Delhi 2nd Edition, 1988.
4. Sheldon M. Ross, Stochastic Processes. 2nd Edition John Wiley and Sons, Inc.2004.
5. A.K. Basu, Introduction to Stochastic Process, Narosa Publishing House, New Delhi, 2003.
6. B.R.Bhat, Stochastic Models in Analysis and Applications, New Age International Pvt.Limited New Delhi, 2001.
7. Gross Donald, Harris Carl M., Fundamentals of Queuing Theory, John Wiley&Sons, Inc, 2004.
8. Paul G. Hoel, Sidney C.Port, Charles's .J Stone, Introduction to Stochastic Processes, Universal, Book stall, New Delhi, 1993.
9. William Feller, An Introduction to Probability Theory and its Applications, Vo1.I, Wiley Eastern Limited, New Delhi, 1988.

Project

Sem. IV **Code : P14MA4PJ**
Total Hrs. : 90 **Credits : 4**

Core Course - Classical Dynamics

No. of hrs.: 90 **Credits: 5**

General Objective:

On completion of this course, the learner will know the properties of different dynamics in nature and the underlying principles

Learning Outcome:

On completion of this course, the learner will be able to understand dynamical systems based on the laws governing oscillations, motions, variations and related physical phenomena.

Unit I

Introductory concepts: The mechanical system - Generalized Coordinates -constraints - virtual work - Energy and momentum.

Unit II

Lagrange's equation: Derivation and examples - Integrals of the Motion – Small oscillations.

Unit III

Special Applications of Lagrange’s Equations: Rayleigh’s dissipation function -impulsive motion - Gyroscopic systems - velocity dependent potentials.

Unit IV

Hamilton's equations: Hamilton's principle - Hamilton’s equations – Other variational principles - phase space.

Unit V

Hamilton - Jacobi Theory: Hamilton's Principal Function – The Hamilton -Jacobi equation - Separability.

Text Book

Classical Dynamics, Donald T. Greenwood, PHI Pvt. Ltd., New Delhi-1985.

Unit I Chapter 1 : Sections 1.1 to 1.5
Unit II Chapter 2 : Sections 2.1 to 2.4
Unit III Chapter 3 : Sections 3.1 to 3.4
Unit IV Chapter 4 : Sections 4.1 to 4.4
Unit V Chapter 5 : Sections 5.1 to 5.3

References

1. H. Goldstein, Classical Mechanics, (2nd Edition), Narosa Publishing House, New Delhi, Reprint 2001.
2. Narayan Chandra Rana&PromodSharad Chandra Joag, Classical Mechanics, Tata McGraw Hill, 1991.

Core Course - Algebraic Number Theory

No. of hrs. : 90 **Credits: 5**

GeneralObjective:

On completion of this course, the learner will be able to understand the algebraic properties of algebraic numbers.

Learning Outcome:

On completion of this course, the learner will have an introduction of results on algebraic congruences and residues.

Unit I

Congruences: Elementary Properties of Congruences - Complete Residue System – Reduced Residue System - Some Applications of Congruences.

Unit II

Algebraic Congruences : Solutions of Congruences - Algebraic Congruences - Solutions of the Problems of the Type ax + by + c = 0 - Simultaneous Congruences.

Unit III

Primitive Roots: Algebraic Congruence - Primitive Roots - Theory of Indices.

Unit IV

Quadratic Residues: Quadratic Residues - Legendre's Symbol.

Unit V

Jacobi's Symbol: Reciprocity Law - Quadratic Residue for Composite Modules - Jacobi's Symbol.

Text Book

K.C. Chowdhury, A First Course in Theory of Numbers, Asian Books Pvt. Ltd., New Delhi, 2004.

Unit I	Sec 2.1 - 2.3	Pages 49 – 70
Unit II	Sec 2.4 - 2.7	Pages 71 – 97
Unit III	Sec 3.1, 3.3, 3.4	Pages 98 - 100,108 – 128
Unit IV	Sec 6.1 - 6.2	Pages 218 – 232
Unit V	Sec 6.3 - 6.4	Pages 233 - 246

References

1. S.B.Malik, Basic Number Theory, Second Edition, Vikas Publishing House Pvt. Ltd., Noida, 2009.
2. George E. Andrews, Number Theory, Courier Dover Publications,1994.

Core Course - Advanced Analysis

No. of hrs.:90 **Credits: 5**

General objectives & Learning outcomes:

On completion of this course, the learner will be able

1. to acquire an understanding of functions of several variables.
2. to apply the techniques used in Real and Complex Analysis in extending the results to 'n' dimensional space.
3. to prove the results on mathematical analysis and to formulate precise mathematical arguments.

Unit I

Functions of several variables – Linear Transformations – Derivatives in an open subset of R^n – Chain rule – Partial Derivatives

Unit II

Interchange of the order of differentiation - Derivatives of higher orders – Taylor's theorem – Inverse function theorem

Unit III

Implicit function theorem – Jacobians – Extremum problems with constraints – Lagrange's multiplier method – Differentiation of Integral – Partitions of unity – Differential forms – Stoke'sTheorem .

Unit IV

Analytic continuation – Uniqueness of direct analytic continuation – Uniqueness of analytic continuation along a curve – Power series method of analytic continuation Schwartz Reflection Principle

Unit V

Monodromy theorem and its consequences – Harmonic functions on a disc –Harnack's Inequality and Theorem – Dirichlet Problem – Green's Function.

Text Books:

1. Walter Rudin, Principles of Mathematical Analysis, McGraw – Hill Book Company, New York, 3rd Edition 1976.
2. Walter Rudin, Real and Complex Analysis, McGraw – Hill Book Co., 1966

References:

1. Tom Apostal, Mathematical Analysis, Addison – Wesley Publishing Company, London 1971.
2. L.V.Ahlfors, Complex Analysis, McGraw-Hill, 1979.

Core Course -Rings and Modules

No. of hrs.:90 **Credits: 5**

General objectives:

On completion of this course, the learner will be able

1. to understand the basic structure and theory of rings and modules
2. to understand the importance of a ring as central objective in algebra
3. to understand the concept of a module as a generalization of a vector space

Learning outcomes:

On completion of this course, the learner will

1. have a clear understanding over the basic structures of Rings and Modules
2. understand the structure of abelian groups through the idea of finitely generated modules.

Unit I

Cyclic Modules - Simple Modules - Semi Simple Modules – Schuler's Lemma – Free Modules

Unit II

Noetherian and Artinian Modules and Rings – Hilbert basis theorem – Wedderburn – Artin Theorem

Unit III

Uniform Modules – Primary Modules – Noether – Lasker Theorem– Smith normal form over a Principal Ideal domain and rank

Unit IV

Fundamental Structure Theorem for finitely generated modules over a Principal Ideal domain and its applications to finitely generated abelian groups

Unit V

Rational canonical form – Generalized Jordan form over any field.

Text Books

1. I.N Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. M. Artin, Algebra, Prentice – Hall of India, 1991

Elective Course - Computational Fluid Dynamics

Total Hrs. : 90 **Credits : 4**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the construction of numerical methods with appropriate meshes to solve problems of fluid flows.
2. know the appropriate packages from the software OCTAVE for solving problems of fluid dynamics.

Unit I

Finite difference methods : Simple methods – general methods – higher order derivatives – multidimensional finite difference formulas – mixed derivatives – non-uniform mesh – higher order accuracy schemes – accuracy of finite difference solutions.

Unit II

Solution methods of finite difference equations : Elliptic equations – finite difference formulation – iterative solution methods – Jacobi and Gauss-Seidal iteration methods – direct method with Gaussian elimination – parabolic equations – explicit schemes – FTCS method – implicit schemes – Lassonen and Crank-Nicolson methods – hyperbolic equations – explicit schemes – Euler's FTFS, FTCS and FTBS schemes – implicit schemes – Euler's FTCS method and Crank-Nickolson method.

Unit III

Finite element methods : General – finite element formulations – definitions of errors – steady state problems – two-dimensional elliptic equations – boundary conditions in two dimensions – solution procedure - Stokes flow problems – transient problems – parabolic equations – hyperbolic equations – multivariable problems.

Practical : Computational methods in OCTAVE

Unit IV

Solving ordinary and partial differential equations using finite difference methods : Elliptic equation – heat conduction – parabolic equation – Couette flow – hyperbolic equations – first order wave equation – second order wave equation.

Unit V

Solving partial differential equations using finite element methods :Solution of Poisson equation with isoparametric elements – parabolic partial differential equation in two dimensions.

Text book

T. J. Chung, Computational Fluid Dynamics, Cambridge Univ. Press, 2003.

Unit I	Chapter 3	§ 3.1-3.8, pg.no. 45-62
Unit II	Chapter 4	§4.1-4.3, 4.7, pg.no. 63-81
Unit III	Chapters 8 & 10	§ 8.1-8.3, 10.1, 10.2, 10.4, pg.no. 243-259, 309-335
Unit IV	Chapter 4	§ 4.7 pg.no. 98-103
Unit V	Chapter 10	§ 10.4 pg.no. 342-345

References

1. C.A J. Fletcher, Computational Techniques for Fluid Dynamics, Vol. I & II, Springer Verlag 1991.
2. Jesper Schmidt Hansen, GNU Octave Beginner's Guide, Packt Publishing, 2011.
3. J Blazek, Computational Fluid Dynamics, Elsevier, 2001.
4. Harvard Lomax, Thomas H. Pulliam, David W Zingg, Fundamentals of Computational Fluid Dynamics, NASA Report, 2006.

Elective Course - Boundary Value Problems

No. of hrs. : 90 **Credits: 4**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the properties of dynamical systems in nature.
2. be able to apply the concepts of ordinary/partial differential equations in various problems in nature.
3. be able to apply the concepts of special functions in problems on fluid motions.

Unit I

Definition of boundary Value Problems, the heat equation, wave equation, Laplace`s equation, the Fourier method, Linear Operators, Principal of Superposition, series solutions, uniform convergence (weierstrass M-test), separation of variables, non homogeneous conditions, Sturm-Liouville problems, formal solutions, the vibrating string.

Unit II

Orthogonal sets of functions, Generalized Fourier series, Best approximation in the mean, Convergence in the mean, the orthonormal trigonometric functions, other types of orthogonality.

Unit III

Sturm-Liouville Problem and applications, orthogonality and uniqueness of eigen functions, method of solutions, surface heat transfer other boundary value problems.

Unit IV

Bessel function Jn, recurrence relation, the zero of J0 (X) and related functions, Fourier-Bessel series, Temperatures in a long cylinder.

Unit V

Legendre polynomials, orthogonality of Legendre polynomials, Legendre series, Dirichlet Problem in spherical regions.

Text Book

R.V. Churchill and J. Brown.: Fourier Series and Boundary Value Problems (8th edtion) McGraw-Hill education, 2011.

Elective Course - MATHLAB

No. of hrs. : 90 **Credits: 4**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the essential commands of MATLAB.
2. know how to solve flow problems using MATLAB.
3. be able to apply SIMULINK in population dynamics, Linear Economic models and Linear Programming Problems

Unit I

MATLAB Basics – Input and Output – Arithmetic – Algebra – Symbolic Expressions, Variable Precision, and Exact Arithmetic – Managing Variables – Errors in Input – Online Help – Variables and Assignments – Solving Equations – Vectors and Matrices - Vectors – Matrices – Suppressing Output – Functions – Built-in functions – User - defined functions - Graphics – The MATLAB Interface – M-Files – Loops

Unit II

Suppressing Output – Data Classes – Functions and Expressions - More about M-Files – Complex Arithmetic – More on Matrices – Doing Calculus with MATLAB – Default variables- MATLAB Graphics – Two- Dimensional Plots – Three - Dimensional Plots- Special Effects – Customizing and Manipulating Graphics – Sound.

Unit III

M-Books - MATLAB Programming – Branching – More about Loops – Other Programming Commands – Interacting with the Operating System .

Unit IV

SIMULLINK and GUIS SIMULINK - Applications – Mortgage Payments – Monte Carlo Simulation - Population Dynamics – Linear Economic Models - Linear Programming – The 360 ° Pendulum.

Unit V

Applications (continued) -Numerical Solution of the Heat Equation – A Model of Traffic flow- Troubleshooting.

Text Book

Brian R.Hunt, Ronald L.Lipsman, Jonathan M. Rosenberg "A guide to MATLAB beginners and Experienced Users", Cambridge University Press edition, 2008.

Unit I Chapter 2 & 3
Unit II Chapter 4 & 5
Unit III Chapter 6 & 7
Unit IV Chapter 8 & 9 upto page 184
Unit V Chapter 9 (Pages 184 to 203) & Chapter 11 **Practicals only**

References

1. Website: www.ann.jussieu.fr/free.htm
2. MATLAB – The language of technical computing, The MATH WORKS Inc., Version 5 1996 (http: \\www.mathworks.com)
3. L.F. Shampine, I.Gladwell, S. Thompson , Solving ODEs with MATLAB, Cambridge University press 2003.

Elective Course - Combinatorics

No. of hrs. : 90 **Credits : 4**

General objective & Learning outcome:

On completion of this course, the learner will be able to understand the concepts in combinatorial analysis and techniques of discrete methods.

Unit I

Counting Methods for selections arrangements : Basic counting principles, simple arrangements and selections, arrangements and selection with repetition , distributions, binomial, generating permutations and combinations and programming projects.

Unit II

Generating function : Generating function models, calculating of generating functions, partitions exponential generating functions, a summation method.

Unit III

Recurrence Relations : Recurrence relation model, divide and conquer relations, solution of inhomogeneous recurrence relation, solution with generating functions.

Unit IV

Inclusion-exclusion : Counting with Venn diagrams inclusion formula, restricted positions and rook polynomials.

Unit V

Ramsey Theory : Ramsey theorem, applications to geometrical problems.

References

1. Alan Tucker, Applied Combinatorics (third edition), John Wiley &sons , New York (1995)
2. V. Krishnamurthy, Combinatorial, Theory and Applications, East West Press, New Delhi (1989) Scientific, (1996)

Post Graduate - Extra Credit Courses
(For the candidates admitted from the academic year 2016 onwards)

Course	Code	Title	Credits	Marks	
				ESA	TOTAL
I	P14MAX:1	Finite Difference Methods	2	100	100
II	P14MAX:2	Information Theory	2	100	100
III	P14MAX:3	Wavelet Theory	2	100	100
IV	P14MAX:4	Theory of Linear Operators	2	100	100
V	P14MAX:5	Mathematical Physics	2	100	100
VI	P15MAX:6	History of Modern Mathematics	2	100	100
VII	P15MAX:7	Research Methodology	2	100	100

Extra Credit Course I - Finite Difference Methods

Code : P14MAX:1 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will be able

1. to understand the discretization of differential equation and to apply to solve differential equations numerically.
2. to analyse the stability theory of system of differential equations.

Unit I

Introduction, Difference Calculus – The Difference Operator, Summation, Generating functions and approximate summation.

Unit II

Linear Difference Equations – First order equations. General results for linear equations. Equations with constant coefficients. Applications, Equations with variable coefficients. Nonlinear equations that can be linearized. The z-transform.

Unit III

Stability Theory – Initial value problems for linear system. Stability of linear system. Stability of nonlinear systems, chaotic behavior.

Unit IV

Boundary value problems for Nonlinear equations – Introduction. The Lipschitz case. Existence of solutions. Boundary value problems for Differential equations.

Unit V

Partial Differential Equation – Discretization of partial Differential Equations – Solution of Partial Differential Equations.

References

1. Walter G. Kelley and Allan C. Peterson – Difference Equations. An Introduction with Applications. Academic press inc., Harcourt Brace Joranovich publishers, 1991.
2. Calvin Ahibrandt and Allan C. Peterson – Discrete Hamiltonian Systems. Difference Equations, Continued Fractions and Riccati Equations. Kluwer, Boston, 1996.

Extra Credit Course II - Information Theory

Code : P14MAX:2 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the classification of channels and their information processes.
2. be able to understand the basic concepts of information theory and coding theory.

Unit I

Measure of Information – Axioms for a measure of uncertainty. The Shannon entropy and its properties. Joint and conditional entropies. Transformation and its properties.

Unit II

Noiseless coding – Ingredients of noiseless coding problem. Uniquely decipherable codes. Necessary and sufficient condition for the existence of instantaneous codes. Construction of optimal codes.

Unit III

Discrete Memory less Channel-Classification of channels. Information processed by a channel. Calculation of channel capacity. Decoding schemes. The ideal observer. The fundamental theorem of information theory and its strong and weak converses.

Unit IV

Continuous Channels – The time-discrete Gaussian channel. Uncertainty of an absolutely continuous random variable. The converse to the coding theorem for time-discrete Gaussian Channel. The time-continuous Gaussian channel. Band-limited channels.

Unit V

Some imuitive properties of measure of entropy-Symmetry, normalization, expansibility, boundedness, recursivity maximality, stability, additivity, subadditivity, nonnegative, continuity, branching etc. and interconnections among them. Axiomatic characterization of Shannon entropy dur to Shannon and Fadeev.

References

1. R.Ash, Information Theory, Inter science Publishers, New York, 1965.
2. F.M.Reza, An Introduction to Information Theory, McGraw-Hill Book Company Inc.,1961.
3. J.Aczel and Z.Daroczy, On Measures of Information and Their Characterization, Academic Press, New York,1975.

Extra Credit Course III - Wavelet Theory

Code : P14MAX:3 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the basic concepts of wavelet theory.
2. be able to understand construction of wavelets.
3. be able to comprehend wavelets on the real line.

Unit I

Different ways of constructing wavelets-Orthonormal bases generated by a single function: the Balian –Low theorem. Smooth projections on L2 (R) .Local sine and cosine bases and the construction of some wavelets. The unitary folding operators and the smooth projections.

Unit II

Multire solution analysis and construction of wavelets. Construction of compactly supported wavelets and estimates for its smoothness. Band limited wavelets.

Unit III

Orthonormality. Completeness. Characterization of Lemarie-Meyer wavelets and some other characterization. Franklin wavelets and Spline wavelets on the real line. Orthonormal bases of piecewise linear continuous functions and Spline wavelets on the real line.

Unit IV

Orthonormal bases of piecewise linear continuous functions for L2(T) Orthonormal bases of periodic splines., Periodizations of wavelets defined on the real line.

Unit V

Characterizations in the theory of wavelets – The basic equations and some of its applications. Characterizations of MRA wavelets, low-pass filters and scaling functions.

References

1. Eugenio Hernandez and Guido Weiss, A First Course on Wavelets, CRC Press, New York,1996.
2. C.K. Chui, An Introduction to Wavelets, Academic Press, 1992
3. I. Daubechies, Ten Lectures on Wavelets, CBS-NSF Regional Conferences. In Applied Mathematics,61, SIAM,1992.
4. Y.Meyer, Wavelets, Algorithms and Applications (translated by R.D.Rayan, SIAM,) 1993.
5. M.V.Wickerhauser, Adapted Wavelet Analysis from Theory to Software, Wellesley, MA,A.K.Peters,1994.
6. Mark A.Pinsky, Introduction to Fourier Analysis and Wavelets, Thomson, 2002.

Extra Credit Course IV - Theory of linear Operators

Code : P14MAX:4 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the theory of linear operators and their properties in normed spaces
2. be able to understand the characteristics of linear operators.

Unit I

Spectral theory of linear operators in normed spaces – Spectral theory on finite dimensional normed spaces – basic concepts – Spectral properties of bounded linear operators – properties of resolvent and spectrum – Banach Algebra.

Unit II

Compact linear operators on normed spaces – properties – Spectral properties of compact linear operators on normed spaces.

Unit III

Operator equations involving compact linear operators – theorems of Fredholm Type – Fredholm alternative.

Unit IV

Spectral properties of bounded self adjoint linear operator – positive operators – square roots of a positive operators.

Unit V

Projection operators – their properties – spectral family of bounded self-adjoint linear operators.

References

1. Erwin Kreyszig, Introductory Functional Analysis with its Applications,John Wiley & Sons; Reprint edition (5 April 1989).
2. K.Yosida, Functional Analysis, Springer-Verlag, 1974.
3. P.R.Halmos, Introduction to Hilbert Space and the Theory of Spectral Multiplicity, second edition, Chelsea Publishing Co., New York, 1957.

Extra Credit Course V - Mathematical Physics

Code : P14MAX: 5 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. be able to comprehend some special mathematical functions and their relevance in other fields.
2. be able to analyse boundary value problems and their applications in other fields.

Unit I

Boundary value problems and series solution – examples of boundary value problems – Eigenvalues, Eigen functions and the Sturm-Liouville problem – Hermitian Operator, their Eigenvalues and Eigen functions.

Unit II

Bessel functions – Bessel functions of the second kind, Hankel functions, Spherical Bessel functions – Legendre polynomials – associated Legendre polynomials and spherical harmonics.

Unit III

Hermit polynomials – Laguerre polynomials – the Gamma function – the Dirac delta function.

Unit IV

Non homogeneous boundary value problems and Green's function – Green's function for one dimensional problems – Eigen function expansion of Green's function.

Unit V

Green's function in higher dimensions – Green's function for Poisson's equation and a formal solution of electrostatic boundary value problems – wave equation with source – the quantum mechanical scattering problem.

References

1. B.D.Gupta, Mathematical Physics, Vikas Publishing House Pvt Ltd., New Delhi, 1993.
2. Goyal AK Ghatak, Mathematical Physics – Differential Equations and Transform Theory, McMillan India Ltd., 1995.
3. Kreyszig, Advanced Engineering Mathematics, Wiley; Ninth edition (2011).

Extra Credit Course VI - History of Modern Mathematics

Code : P15MAX:6 **Credits : 2**

General objectives:

On completion of this course, the learner will

1. know the prominent movements in modern mathematics.
2. know the mathematicians' work and their valuable contributions.

Learning outcomes:

On completion of this course, the learner will

1. be motivated to continue the line of innovative thinking
2. have a better understanding over the concepts and the interlinks

Unit I

Theory of Numbers – Irrational and transcendent numbers - Complex numbers.

Unit II

Quaternions and Ausdehnungslehre – Theory of equations – Substitutions and groups.

Unit III

Determinants – Quantics – Calculus – Differential Equations.

Unit IV

Infinite series – Theory of functions – Probabilities and least squares.

Unit V

Analytic geometry – Modern geometry – Elementary geometry – Non-Euclidean geometry.

Reference

1. David Eugene Smith, History of Modern Mathematics, MJP Publishers, 2008.

Extra Credit Course VII - Research Methodology

Code : P15MAX:7 **Credits : 2**

General objectives:

On completion of this course, the learner will

1. know the process of academic writing.
2. know to write a thesis.

Learning outcome:

On completion of this course, the learner will be able to prepare a research article to report his/her research findings

Unit I

The research thesis –The intellectual content of the thesis –Typing, organizing and developing the thesis.

Unit II

Grammar, punctuation and conventions of academic writing – Layout of the thesis – The preliminary pages and the introduction.

Unit III

Literature review –Methodology .

Unit IV

The data analysis –The conclusion.

Unit V

Completing the thesis – Publishing findings during preparation of the thesis.

Reference

1. Paul Oliver, Writing Your Thesis, Sage Publication, 2nd edition 2008.