Post- Graduate Programme
in Mathematics

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

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

2023 – 2024

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	Hours
Part I			
Core	12	56	73
Core Project	1	7	8
Elective	6	19	26
Part II			
PCS	1	2	4
NMEC	2	4	7
Internship	1	2	-
Part III			
Extension Activity	1	1	-
VLO	1	2	2
Total	**25**	**93**	**120**

List of Core Courses

1. Algebraic Structures
2. Real Analysis I
3. Ordinary Differential Equations
4. Advanced Algebra
5. Real Analysis II
6. Partial Differential Equations
7. Complex Analysis
8. Probability Theory
9. Topology
10. Industrial Mathematics
11. Functional Analysis
12. Differential Geometry
13. Project with Viva Voce

List of Elective Courses

1. Graph Theory and Applications
2. Calculus of Variations and Integral Equations
3. Fluid Dynamics
4. Introduction to Python Programming
5. Resource Management Techniques
6. Statistical Data Analysis using R Programming

List of Professional Competency Skill Course (PCS)

1. Training for Competitive Examinations

List of Non-Major Elective Course (NMEC)

1. Operations Research for Management
2. Statistics with R Programming

Extra Credit Courses

1. Fuzzy Sets and Their Applications
2. Stochastic Processes
3. Wavelet Theory
4. Mathematical Physics

M. Sc. Mathematics – Curriculum Structure
(For the Students Admitted from the Year 2023 onwards)

Sem.	Course	Course Code	Course Title	Hrs. / Week	Credits	Marks		
						CIA	ESA	Total
I	Core I	P23MA101	Algebraic Structures	7	5	25	75	100
	Core II	P23MA102	Real Analysis I	7	5	25	75	100
	Core III	P23MA103	Ordinary Differential Equations	6	4	25	75	100
	Elective I	P23MA1:A	Graph Theory and Applications	5	3	25	75	100
	Elective II	P23MA1:B	Calculus of Variations and Integral Equations	5	3	25	75	100
				30	**20**			
II	Core IV	P23MA204	Advanced Algebra	6	5	25	75	100
	Core V	P23MA205	Real Analysis II	6	5	25	75	100
	Core VI	P23MA206	Partial Differential Equations	6	4	25	75	100
	Elective III	P23MA2:A	Fluid Dynamics	4	3	25	75	100
	Elective IV	P23MA2:P	Introduction to Python Programming	4	3	40	60	100
	NMEC I	P23MA2E1	Operations Research for Management	4	2	25	75	100
				30	**22**			
III	Core VII	P23MA307	Complex Analysis	6	5	25	75	100
	Core VIII	P23MA308	Probability Theory	6	5	25	75	100
	Core IX	P23MA309	Topology	6	5	25	75	100
	Core X	P23MA310	Industrial Mathematics	5	4	25	75	100
	Elective V	P23MA3:A	Resource Management Techniques	4	3	25	75	100
	NMEC II	P23MAPE2	Statistics with R Programming	3	2	40	60	100
	Internship / Industrial Activity	P23MA3I1	Carried out in I Year Summer vacation (30 Hours)	-	2	-	-	100
				30	**26**			
IV	Core XI	P23MA411	Functional Analysis	6	5	25	75	100
	Core XII	P23MA412	Differential Geometry	6	5	25	75	100
	Core Project	P23MA 4PJ	Project with Viva Voce	8	7	40	60	100
	Elective VI	P23MA4:P	Statistical Data Analysis using R Programming	4	3	40	60	100
	PCS	P23MA4S1	Training for Competitive Examinations	4	2	-	-	100
	Extension Activity	P23ETA41		-	1	-	-	-
	VLO	P23VLO41 / P23VLO42	Value Education (RI / MI)	2	2	-	-	100
				30	**25**			

Total Credits : 93

NMEC – Non-Major Elective Course

PCS - Professional Competency Skill

CIA- Continuous Internal Assessment **ESA-** End Semester Assessment

Core I – Algebraic Structures

Semester: I **Code: P23MA101**
Hrs. / Week: 7 **Credits: 5**

Pre-requisite: UG level Modern Algebra

Objectives of the Course:

To introduce the concepts and to develop working knowledge on class equation, solvability of groups, finite abelian groups, linear transformations, real quadratic forms.

Course Outline:

Unit-I

Another Counting Principle - Class equation for finite groups and its applications - Sylow's theorems (For theorem 2.12.1, First proof only).

Unit-II

Solvability by Radicals - Direct products - Finite abelian groups- Modules

Unit-III

Linear Transformations: Canonical forms –Triangular form - Nilpotent transformations.

Unit-IV

Jordan form - rational canonical form.

Unit-V

Trace and transpose - Hermitian, unitary, normal transformations, real quadratic form.

Text Books:

I.N. Herstein. Topics in Algebra (II Edition) Wiley Eastern Limited, New Delhi, 1975.

Unit I	Chapter 2 § 2.11- 2.12 (Omit Lemma 2.12.5)
Unit II	Chapter 5 § 5.7 (Lemma 5.7.1, Lemma 5.7.2, Theorem 5.7.1)
	Chapter 2: § 2.13 and 2.14 (Theorem 2.14.1 only);
	Chapter 4: § 4.5
Unit III	Chapter 6 § 6.4, 6.5
Unit IV	Chapter 6 § 6.6 and 6.7
Unit V	Chapter 6 § 6.8, 6.10 and 6.11 (Omit 6.9)

References:

1. M.Artin, Algebra, Prentice Hall of India, 1991.
2. P.B.Bhattacharya, S.K.Jain, and S.R.Nagpaul, Basic Abstract Algebra (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. I.S.Luther and I.B.S.Passi, Algebra, Vol. I –Groups(1996); Vol. II Rings, Narosa Publishing House , New Delhi, 1999
4. D.S.Malik, J.N. Mordeson and M.K.Sen, Fundamental of Abstract Algebra, McGraw Hill (International Edition), New York. 1997.

5. N.Jacobson, Basic Algebra, Vol. I & II W.H.Freeman (1980); also published by Hindustan Publishing Company, New Delhi.

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. www.algebra.com

Core II – Real Analysis I

Semester: I **Code: P23MA102**
Hrs. / Week: 7 **Credits: 5**

Pre-requisite: UG level real analysis concepts

Objectives of the Course:

To work comfortably with functions of bounded variation, Riemann-Stieltjes Integration, convergence of infinite series, infinite product and uniform convergence and its interplay between various limiting operations.

Course Outline:

Unit-I:

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

Infinite Series: Absolute and conditional convergence - Dirichlet's test and Abel's test - Rearrangement of series - Riemann's theorem on conditionally convergent series.

Unit-II :

The Riemann - Stieltjes Integral - Introduction - Notation - The definition of the Riemann - Stieltjes integral - Linear Properties - Integration by parts- Change of variable in a Riemann - Stieltjes integral - Reduction to a Riemann Integral – Euler's summation formula - Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper, lower integrals - Riemann's condition - Comparison theorems.

Unit-III :

The Riemann-Stieltjes Integral - Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of RS integrals-Mean value theorems -integrals as a function of the interval – Second fundamental theorem of integral calculus-Change of variable -Second Mean Value Theorem for Riemann integral-Riemann-Stieltjes integrals depending on a parameter- Differentiation under integral sign-Lebesgue criterion for existence of Riemann integrals.

Unit-IV :

Infinite Series and infinite Products - Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series – Cesaro summability - Infinite products.

Power series - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem - Tauber's theorem

Unit-V:

Sequences of Functions – Pointwise convergence of sequences of functions - Examples of sequences of real - valued functions - Uniform convergence and continuity - Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions - Riemann - Stieltjes integration – Non-uniform Convergence and Term-by-term Integration - Uniform convergence and differentiation - Sufficient condition for uniform convergence of a series - Mean convergence.

Text Books:

Tom M.Apostol : Mathematical Analysis, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974.

Unit I	Chapter 6 § 6.1 to 6.8
	Chapter 8 § 8.8, 8.15, 8.17, 8.18
Unit II	Chapter 7 § 7.1 to 7.14
Unit III	Chapter 7 § 7.15 to 7.26
Unit IV	Chapter 8 § 8.20, 8.21 to 8.26
	Chapter 9 § 9.14, 9.15, 9.19, 9.20, 9.22, 9.23
Unit V	Chapter 9 § 9.1 to 9.6, 9.8,9.9,9.10,9.11, 9.13

References:

1. Bartle, R.G. Real Analysis, John Wiley and Sons Inc., 1976.
2. Rudin,W. Principles of Mathematical Analysis, 3rd Edition. McGraw Hill Company, New York, 1976.
3. Malik,S.C. and Savita Arora. Mathematical Analysis, Wiley Eastern Limited. New Delhi, 1991.
4. Sanjay Arora and Bansi Lal, Introduction to Real Analysis, Satya Prakashan, New Delhi, 1991.
5. Gelbaum, B.R. and J. Olmsted, Counter Examples in Analysis, Holden day, San Francisco, 1964.
6. A.L.Gupta and N.R.Gupta, Principles of Real Analysis, Pearson Education, (Indian print) 2003.

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. www.mathpages.com

Core III – Ordinary Differential Equations

Semester: I **Code: P23MA103**
Hrs. / Week: 6 **Credits: 4**

Pre-requisite: UG level Calculus and Differential Equations

Objectives of the Course:

To develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points, to study existence and uniqueness of the solutions of first order differential equations

Course Outline:

Unit-I : Linear equations with constant coefficients

Second order homogeneous equations-Initial value problems-Linear dependence and independence-Wronskian and a formula for Wronskian-Non-homogeneous equation of order two.

Unit-II : Linear equations with constant coefficients

Homogeneous and non-homogeneous equation of order n –Initial value problems- Annihilator method to solve non-homogeneous equation- Algebra of constant coefficient operators.

Unit-III : Linear equation with variable coefficients

Initial value problems -Existence and uniqueness theorems – Solutions to solve a non-homogeneous equation – Wronskian and linear dependence – reduction of the order of a homogeneous equation – homogeneous equation with analytic coefficients-The Legendre equation.

Unit-IV : Linear equation with regular singular points

Euler equation – Second order equations with regular singular points –Exceptional cases – Bessel Function.

Unit-V : Existence and uniqueness of solutions to first order equations

Existence and uniqueness of solutions to first order equations: Equation with variable separated – Exact equation – method of successive approximations – the Lipschitz condition – convergence of the successive approximations and the existence theorem.

Text Books:

E.A. Coddington, A introduction to ordinary differential equations (3rd Printing) Prentice-Hall of India Ltd., New Delhi, 1987.

Unit I	Chapter 2 § 1 to 6
Unit II	Chapter 2 § 7 to 12
Unit III	Chapter 3 § 1 to 8 (Omit section 9)
Unit IV	Chapter 4 § 1 to 4 and 6 to 8 (Omit sections 5 and 9)
Unit V	Chapter 5 § 1 to 6 (Omit Sections 7 to 9)

References:

1. Williams E. Boyce and Richard C. DI Prima, Elementary differential equations and boundary value problems, John Wiley and sons, New York, 1967.
2. George F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, New Delhi, 1974.
3. N.N. Lebedev, Special functions and their applications, Prentice Hall of India, New Delhi, 1965.
4. W.T. Reid. Ordinary Differential Equations, John Wiley and Sons, New York, 1971
5. M.D.Raisinghania, Advanced Differential Equations, S.Chand & Company Ltd. New Delhi 2001
6. B.Rai, D.P.Choudary and H.I. Freedman, A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi, 2002.

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. www.mathpages.com

Elective I – Graph Theory and Applications

Semester: I **Code: P23MA1:A**
Hrs. / Week: 5 **Credits: 3**

General Objectives:

To understand the concepts of Graph theory and to know the applications of graphs in other disciplines.

Course Outline

Unit I: Paths and Connections, Cycles, The Shortest Path Problem Trees , Cayley's formula, The Connector Problem.

Unit II: Euler Tours, Hamilton cycles, The Chinese Postman Problem, The Travelling Salesman problem.

Unit III: Edge Chromatic number, Vizing's Theorem, The Timetabling Problem, Independent Sets, Ramsey's Theorem, Turan's Theorem, Schur's Theorem.

Unit IV: Chromatic number, Brook's theorem, Hajos conjecture, Chromatic Polynomials, A Storage Problem, Plane and Planar Graphs, Dual Graphs, Euler's formula.

Unit V: The Five Colour Theorem and Four Colour Conjecture, A Planarity Algorithm, Directed Graphs, Directed Paths, Directed Cycles, A Job Sequencing Problem.

Text Book:

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

Unit I	Chapter 1: 1.6, 1.7, 1.8
	Chapter 2: 2.1, 2.4, 2.5
Unit II	Chapter 4: 4.1,4.2,4.3,4.4
Unit III	Chapter 6: 6.1, 6.2, 6.3
	Chapter 7: 7.1, 7.2, 7.3, 7.4
Unit IV	Chapter 8: 8.1, 8.2, 8.3, 8.4, 8.6
	Chapter 9: 9.1, 9.2, 9.3
Unit V	Chapter 9: 9.6, 9.8
	Chapter 10: 10.1,10.2,10.3,10.4

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.

Website and e-Learning Source

1. https://swayam.gov.in/explorer?searchText=GRAPH+THEORY
2. https://nptel.ac.in/courses/111/106/111106102/

Elective II – Calculus of Variations and Integral Equations

Semester: I **Code: P23MA1:B**
Hrs. / Week: 5 **Credits: 3**

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 use Green's function in reducing boundary value problems to integral equations.

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.

Course Outline:

Unit-I:

The Calculus of Variations Introduction – 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 – Isoperimetric problems – The general variation of a functional – Variational problems with moving boundaries.

Unit-III:

Hamilton's principle – Lagrange's equations – Sturm-Liouville's problem and Variational Methods (Rayleigh's Principle) – The Ritz Method.

Unit-IV:

Integral Equations – Introduction – 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.

Unit-V:

Fredholm equations with separable kernels – Fredholm equations with symmetric kernels : Hilbert Schmidt theory – Iterative methods for the solution of integral equations.

Text Book:

Dr. M.K.Venkataraman, Higher Mathematics for Engineering and Sciences, The National publishing Company, 2001 (Unit I, II, III ,IV and V).

Unit I	Chapter 9 § 1 – 11
Unit II	Chapter 9 § 12 – 17
Unit III	Chapter 9 § 18 – 21
Unit IV	Chapter 10 § 1 – 5
Unit V	Chapter 10 § 6 – 9

References:

1. Francis. B. Hildebrand, Methods of Applied Mathematics, Prentice-Hall of India Pvt. Ltd., New Delhi, Second Edition 1968.

2. Krasnov, Kiselu and Marenko, Problems and Exercises in Integral Equations, MIR Publishers, 1971.

3. Ram. P. Kanwal, Linear Integral Equations - Theory and Techniques, Academic Press, New York, 1971.

Core IV – Advanced Algebra

Semester: II **Code: P23MA204**
Hrs. / Week: 6 **Credits: 5**

Pre-requisite: Algebraic Structures

Objectives of the Course:

To study field extension, roots of polynomials, Galois Theory, finite fields, division rings, solvability by radicals and to develop computational skill in abstract algebra.

Course Outline:

Unit-I :
Extension fields – Transcendence of e.

Unit-II :
Roots or Polynomials - More about roots.

Unit-III :
Elements of Galois theory.

Unit-IV :
Finite fields - Wedderburn's theorem on finite division rings.

Unit-V :
Solvability by radicals - A theorem of Frobenius - Integral Quaternions and the Four - Square theorem.

Text Books:

I.N. Herstein. Topics in Algebra (II Edition) Wiley Eastern Limited, New Delhi, 1975.

Unit I	Chapter 5 § 5.1 and 5.2
Unit II	Chapter 5 § 5.3 and 5.5
Unit III	Chapter 5 § 5.6
Unit IV	Chapter 7 § 7.1 and 7.2 (Theorem 7.2.1 only)
Unit V	Chapter 5 § 5.7 (omit Lemma 5.7.1, Lemma 5.7.2 and Theorem 5.7.1); Chapter 7 § 7.3 and 7.4

References:

1. M.Artin, Algebra, Prentice Hall of India, 1991.
2. P.B.Bhattacharya, S.K.Jain, and S.R.Nagpaul, Basic Abstract Algebra (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. I.S.Luther and I.B.S.Passi, Algebra, Vol. I –Groups(1996); Vol. II Rings,Narosa Publishing House , New Delhi, 1999
4. D.S.Malik, J.N. Mordeson and M.K.Sen, Fundamental of Abstract Algebra, McGraw Hill (International Edition), New York. 1997.
5. N.Jacobson, Basic Algebra, Vol. I & II Hindustan Publishing Company, New Delhi.

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. www.algebra.com

Core V – Real Analysis II

Semester: II **Code: P23MA205**
Hrs. / Week: 6 **Credits: 5**

Pre-requisite: Elements of Real Analysis

Objectives of the Course:

To introduce measure on the real line, Lebesgue measurability and integrability, Fourier Series and Integrals, in-depth study in multivariable calculus.

Course Outline:

Unit-I :

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

Unit-II :

Integration of Functions of a Real variable - Integration of Non- negative functions - The General Integral - Riemann and Lebesgue Integrals.

Unit-III : Abstract Measure Space

Measures and outer measures – Extension of a measure – Uniqueness of the extension – Completion of a measure – Measure spaces – Integration with respect to a measure.

Unit-IV :

Multivariable Differential Calculus - Introduction - The Directional derivative - Directional derivative and continuity - The total derivative - The total derivative expressed in terms of partial derivatives - The matrix of linear function - The Jacobian matrix - The chain rule - Matrix form of chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives - Taylor's theorem for functions of R^n to R^1.

Unit-V :

Implicit Functions and Extremum Problems : Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem-Extrema of real valued functions of severable variables-Extremum problems with side conditions.

Text Books:

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

   Unit I Chapter 2 § 2.1 to 2.5 (de Barra)
   Unit II Chapter 3 § 3.1, 3.2 and 3.4 (de Barra)
   Unit III Chapter 5 § 5.1 to 5.6 (de Barra)
   Unit IV Chapter12 § 2.1 to 12.14 (Apostol)
   Unit V Chapter 13 §13.1 to 13.7 (Apostol)

References:

1. Burkill,J.C.The Lebesgue Integral, Cambridge University Press, 1951.
2. Munroe,M.E.Measure and Integration. Addison-Wesley, Mass.1971.
3. Roydon,H.L.Real Analysis, Macmillan Pub. Company, New York, 1988.
4. Rudin, W. Principles of Mathematical Analysis, McGraw Hill Company, New York,1979.
5. Malik,S.C. and Savita Arora. Mathematical Analysis, Wiley Eastern Limited. New Delhi, 1991.
6. Sanjay Arora and Bansi Lal, Introduction to Real Analysis, Satya Prakashan, New Delhi, 1991

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1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org

Core VI – Partial Differential Equations

Semester: II **Code: P23MA206**
Hrs. / Week: 6 **Credits: 4**

Pre-requisite: UG level partial differential equations

Objectives of the Course:

To classify the second order partial differential equations and to study Cauchy problem, method of separation of variables, boundary value problems.

Course Outline:

Unit-I :

Mathematical Models and Classification of second order equation : Classical equations- Vibrating string – Vibrating membrane – waves in elastic medium – Conduction of heat in solids – Gravitational potential – Second order equations in two independent variables – canonical forms – equations with constant coefficients – general solution

Unit-II :

Cauchy Problem : The Cauchy problem – Cauchy-Kowalewsky theorem – Homogeneous wave equation – Initial Boundary value problem- Non-homogeneous boundary conditions – Finite string with fixed ends – Non-homogeneous wave equation – Riemann method – Goursat problem – spherical wave equation – cylindrical wave equation.

Unit-III :

Method of separation of variables: Separation of variable- Vibrating string problem – Existence and uniqueness of solution of vibrating string problem - Heat conduction problem – Existence and uniqueness of solution of heat conduction problem – Laplace and beam equations

Unit-IV :

Boundary Value Problems : Boundary value problems – Maximum and minimum principles – Uniqueness and continuity theorem – Dirichlet Problem for a circle , a circular annulus, a rectangle – Dirichlet problem involving Poisson equation – Neumann problem for a circle and a rectangle.

Unit-V :

Green's Function: The Delta function – Green's function – Method of Green's function – Dirichlet Problem for the Laplace and Helmholtz operators – Method of images and eigen functions – Higher dimensional problem – Neumann Problem.

Text Book:

1. TynMyint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers (Fourth Edition), North Hollan, New York, 2007.

Unit I	Chapter 3 § 3.1 to 3.6
	Chapter 4 § 4.1 to 4.4, 4.5
Unit II	Chapter 5 § 5.1 to 5.11
Unit III	Chapter 7 § 7.1 to 7.7
Unit IV	Chapter 9 § 9.1 to 9.9
Unit V	Chapter 11 § 11.1 to 11.9

References:

1. M.M.Smirnov, Second Order partial Differential Equations, Leningrad, 1964.
2. I.N.Sneddon, Elements of Partial Differential Equations, McGraw Hill, New Delhi, 1983.
3. R. Dennemeyer, Introduction to Partial Differential Equations and Boundary Value Problems, McGraw Hill, New York, 1968.
4. M.D.Raisinghania, Advanced Differential Equations, S.Chand & Company Ltd., New Delhi, 2001.
5. S, Sankar Rao, Partial Differential Equations, 2nd Edition, Prentice Hall of India, New Delhi. 2004

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. www.mathpages.com

Elective III - Fluid Dynamics

Semester: II **Code: P23MA2:A**

Hrs. / Week: 4 **Credits: 3**

Objectives of the Course:

1. To understand the kinematics of a fluid through equations of motion of the fluid.
2. To analyse some two dimensional and three-dimensional flows.
3. To understand Navier- Stokes equations of motion of a viscous fluid and some solvable problems in viscous flow.
4. 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 analyze the technical characteristics like pressure, velocity, viscosity of two dimensional and three-dimensional flows and their media.

Course Outline:

Unit I

Real fluids and Ideal Fluids – Velocity of a fluid at a point – Streamlines and Path lines: 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 IV - Introduction to Python Programming

Semester: II **Code: P23MA2:P**
Hrs. / Week: 4 **Credits: 3**

Objectives of the Course:

On completion of this course, the learner will

- know the different commands and packages available in Python programming.
- identify their applications in different computational and statistical studies.

List of Practicals:

1. a) Write a Python program to check the Largest among the given three numbers.
   b) Write a function to find the HCF of some given numbers.
2. a) Write a Python program to compute the Factorial of a given number using Recursion.
   b) Write a function to display Fibonacci sequence using Recursion.
3. Write a Python program to solve f(x) = 0 using Bisection method.
4. Write a Python program to solve y' = f(x, y) with given initial conditions using RK method.
5. Write a Python program that demonstrates the Built-in Functions.
6. Write a Python program to demonstrate various String Functions and Operations.
7. Write a Python program to demonstrate List Functions and Operations.
8. Write a Python program to demonstrate the Tuples Functions and Operations.
9. Write a Python program to demonstrate the Dictionaries Functions and Operations.
10. Write a Python program to demonstrate the File and file I/O operations.
11. Write a Python program to demonstrate Classes and their Attributes.
12. Write a Python program to demonstrate Inheritance and Method Overriding.
13. Line plot, Bar chart, Histogram, Scatter plot, Pie chart, Contour plot, Subplots.

References:

1. E. Balagurusamy, Introduction to Computing and Problem Solving Using Python, McGraw Hill Education (India) Private Limited, 2021.
2. Jann Kiusalaas, Numerical Methods in Engineering with Python 3, Cambridge University Press, 2013.
3. Dr. Ossama Embarak, Data Analysis and Visualization Using Python, Apress, UAE, 2018.
4. Charles R. Severance, Python for Everybody – Exploring Data in Python3, Shroff Publishers & Distributors PVT. Ltd, 2018.
5. Qingkai Kong, Timmy Siauw and Alexandre M. Bayen, Python Programming and Numerical Methods - A Guide for Engineers and Scientists, Academic Press, 2021.
6. Ashwin Pajankar, Practical Python Data Visualization: A Fast Track Approach to Learning Data Visualization with Python, India, 2021.

Core VII – Complex Analysis

Semester: III **Code: P23MA307**
Hrs. / Week: 6 **Credits: 5**

Pre-requisite: UG level Complex Analysis

Objectives of the Course:

To Study Cauchy integral formula, local properties of analytic functions, general form of Cauchy's theorem and evaluation of definite integral and harmonic functions

Course Outline:

Unit-I : Cauchy's Integral Formula:

The Index of a point with respect to a closed curve – The Integral formula – Higher derivatives. Local Properties of analytical Functions:

Removable Singularities-Taylors's Theorem – Zeros and poles – The local Mapping – The Maximum Principle.

Unit-II : The general form of Cauchy's Theorem :

Chains and cycles - Simple Connectivity - Homology - The General statement of Cauchy's Theorem - Proof of Cauchy's theorem - Locally exact differentials- Multiply connected regions - Residue theorem - The argument principle.

Unit-III : Evaluation of Definite Integrals and Harmonic Functions

Evaluation of definite integrals - Definition of Harmonic function and basic properties - Mean value property - Poisson formula.

Unit-IV : Harmonic Functions and Power Series Expansions:

Schwarz theorem - The reflection principle - Weierstrass theorem – Taylor's Series – Laurent series.

Unit-V: Partial Fractions and Entire Functions:

Partial fractions - Infinite products – Canonical products – Gamma Function- Jensen's formula – Hadamard's Theorem.

Text Books:

Lars V. Ahlfors, Complex Analysis, (3rd edition) McGraw Hill Co., New York, 1979

Unit I	Chapter 4 § 2: 2.1 to 2.3
	Chapter 4 § 3: 3.1 to 3.4
Unit II	Chapter 4 § 4: 4.1 to 4.7
	Chapter 4 § 5: 5.1 and 5.2

Unit III Chapter 4 § 5: 5.3
Chapter 4 § 6: 6.1 to 6.3
Unit IV Chapter 4 § 6.4 and 6.5
Chapter 5 § 1.1 to 1.3
Unit V Chapter 5 § 2.1 to 2.4
Chapter 5 § 3.1 and 3.2

References:

1. H.A. Presfly, Introduction to complex Analysis, Clarendon Press, oxford, 1990.
2. J.B. Conway, Functions of one complex variables Springer - Verlag, International student Edition, Naroser Publishing Co.1978
3. E. Hille, Analytic function Theory (2 vols.), Gonm & Co, 1959.
4. M.Heins, Complex function Theory, Academic Press, New York,1968.

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. http://en.wikipedia.org

Core VIII – Probability Theory

Semester: III **Code: P23MA308**
Hrs. / Week: 6 **Credits: 5**

Pre-requisite: UG level algebra and calculus

Objectives of the Course:

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

Course Outline:

Unit-I : Random Events and Random Variables:

Random events – Probability axioms – Combinatorial formulae – conditional probability – Bayes Theorem – Independent events – Random Variables – Distribution Function – Joint Distribution – Marginal Distribution – Conditional Distribution – Independent random variables – Functions of random variables.

Unit-II : Parameters of the Distribution :

Expectation- Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors – Regression of the first and second types.

Unit-III: Characteristic functions :

Properties of characteristic functions – Characteristic functions and moments – semi0invariants – characteristic function of the sum of the independent random variables – Determination of distribution function by the Characteristic function – Characteristic function of multidimensional random vectors – Probability generating functions.

Unit-IV : Some Probability distributions:

One point , two point , Binomial – Polya – Hypergeometric – Poisson (discrete) distributions – Uniform – normal gamma – Beta – Cauchy and Laplace (continuous) distributions.

Unit-V: Limit Theorems :

Stochastic convergence – Bernoulli law of large numbers – Convergence of sequence of distribution functions – Levy-Cramer Theorems – de Moivre-Laplace Theorem – Poisson, Chebyshev, Khintchine Weak law of large numbers – Lindberg Theorem – Lapunov Theroem – Borel-Cantelli Lemma - Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.

Text Book:

M. Fisz, Probability Theory and Mathematical Statistics, John Wiley and Sons, New York, 1963.

Unit I	Chapter 1 § 1.1 to 1.7
	Chapter 2 § 2.1 to 2.9
Unit II	Chapter 3 § 3.1 to 3.8
Unit III	Chapter 4 § 4.1 to 4.7
Unit IV	Chapter 5 § 5.1 to 5.10 (Omit Section 5.11)
Unit V	Chapter 6 § 6.1 to 6.4, 6.6 to 6.9, 6.11 and 6.12.
	(Omit Sections 6.5,6.10,6.13 to 6.15)

References:

1. R.B. Ash, Real Analysis and Probability, Academic Press, New York, 1972
2. K.L.Chung, A course in Probability, Academic Press, New York, 1974.
3. R.Durrett, Probability : Theory and Examples, (2nd Edition) Duxbury Press, New York, 1996.
4. V.K.Rohatgi An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi, 1988(3rd Print).
5. S.I.Resnick, A Probability Path, Birhauser, Berlin,1999.
6. B.R.Bhat , Modern Probability Theory (3rd Edition), New Age International (P)Ltd, New Delhi, 1999

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. http://www.probability.net

Core IX – Topology

Semester: III **Code: P23MA309**
Hrs. / Week: 6 **Credits: 5**

Pre-requisite: Real Analysis

Objectives of the Course:

To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.

Course Outline:

Unit-I : Topological spaces :

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

Unit-II : Continuous functions:

Continuous functions – the product topology – The metric topology.

UNIT-III : Connectedness:

Connected spaces- connected subspaces of the Real line – Components and local connectedness.

Unit-IV : Compactness :

Compact spaces – compact subspaces of the Real line – Limit Point Compactness – Local Compactness.

Unit-V: Countability and Separation Axiom:

The Countability Axioms – The separation Axioms – Normal spaces – The Urysohn Lemma – The Urysohnmetrization Theorem – The Tietz extension theorem.

Text Books:

James R. Munkres, Topology (2nd Edition) Pearson Education Pve. Ltd., Delhi-2002 (Third Indian Reprint)

Unit I Chapter 2 § 12 to 17
Unit II Chapter 2 § 18 to 21 (Omit Section 22)
Unit III Chapter 3 § 23 to 25.
Unit IV Chapter 3 § 26 to 29.
Unit V Chapter 4 § 30 to 35.

References:

1. J. Dugundji, Topology, Prentice Hall of India, New Delhi, 1975.

2. George F.Sinmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Co., 1963
3. J.L. Kelly, General Topology, Van Nostrand, Reinhold Co., New York
4. L.Steen and J.Subhash, Counter Examples in Topology, Holt, Rinehart and Winston, New York, 1970.
5. S.Willard, General Topology, Addison - Wesley, Mass., 1970

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. http://en.wikipedia.org

Core X – Industrial Mathematics

Semester: III **Code: P23MA310**
Hrs. / Week: 5 **Credits: 3**

Pre-requisite: UG level probability concepts

Objectives of the Course:

1. Understand the concepts of Stochastic processes, Markov chain and its real-life applications.
2. Understand the concepts of sample moments and analyze the significance tests.

Course Outline:

UNIT I: Stochastic Processes

Some notions - Specifications of stochastic processes- Stationary processes- Markov Chains – Definition and examples-Higher transition probabilities.

UNIT II: Markov Chains

Generalization of Independent Bernoulli trials- Sequences of chain –Dependent trails - Classification of states and chains - determination of higher transition probabilities - Stability of Markov system - Graph theoretic approach - Markov chain with denumerable number of states.

UNIT III: Markov Process with Discrete State Space

Poisson process: Poisson process and related distributions – Generalizations of Poisson process – Birth and death process – Markov process with discrete state space (Continuous time Markov chain).

UNIT IV: Sample Moments and Their Functions

The notion of a sample and a statistic – The distribution of the arithmetic mean of independent normally distributed random variables – The chi-square distribution - The distribution of the statistic – Student's t-distribution – Fisher's Z – distribution

UNIT V: Significance Tests

The concept of a statistical test – Parametric tests for small samples - Parametric tests for large samples – The chi-square test – Tests of the Kolmogorov and Smirnov type.

Text Books:

1. Medhi J. (1994), Stochastic Processes, Second Edition, Wiley Eastern Ltd New Delhi. (Units I, II, III)
2. M. Fisz, Probability Theory and Mathematical Statistics, John Wiley Sons, New York, 1963. (Units IV, V)

Unit I:	Chapter 2 (Sections 2.1 to 2.3) & Chapter 3 (Sections 3.1, 3.2)
Unit II:	Chapter 3 (Sections 3.3 to 3.8)
Unit III:	Chapter 4 (Sections 4.1 to 4.5)
Unit IV:	Chapter 9 (Sections 9.1 to 9.7)
Unit V:	Chapter 12 (Sections 12.1 to 12.5)

Reference Text:

1. Samuel Karlin & Howard M.Taylor(1981.), A First Course in Stochastic Processes, Academic Press.
2. Samuel Karlin & Howard M.Taylor(1981), A Second Course in Stochastic Processes, Academic Press.
3. Sheldon M. Ross, A First Course in Probability, John Wiley and Sons, Inc.2004.

Website and e-Learning Source

1. https://swayam.gov.in/
2. https://nptel.ac.in/
3. http://home.iitk.ac.in/~skb/qbook/solution.html

Elective V Resource Management Techniques

Semester: IV **Code: P23MA3:A**
Hrs. / Week: 4 **Credits: 4**

Objectives of the Course:

1. To know methods of solving Integer Programming problems and multistage programming.
2. To know methods of using Operations Research techniques in decision making
3. 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.

Course Outline:

UNIT I: Integer Programming:

Methods of Integer Programming – Cutting-Plane Algorithms – Branch and Bound Method – Zero-One Implicit Enumeration.

UNIT II: Dynamic (Multistage) Programming:

Elements of the DP model-The Capital Budgeting Example – More on the Definition of the State – Examples of DP Models and Computations – Problem of Dimensionality in Dynamic Programming – Solution of Linear Programs by Dynamic Programming.

UNIT III: Decision Theory and Games:

Decisions under Risk – Decision Tree – Decision under uncertainty – Game Theory

UNIT IV: Inventory Models:

A Generalized Inventory Model - Types of Inventory models –Deterministic Models – Probabilistic Models.

UNIT V: Non-linear Programming algorithms:

Unconstrained Nonlinear Algorithms - Constrained Nonlinear Algorithms

Textbook(s):

1. Hamdy M. Taha, Operations Research, Prentice Hall, New Delhi, 2000.

   Unit I : Chapter 8 : 8.2 – 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 – 19.3

Reference Book:

1. Kanti Swarup, P. K. Gupta, Man Mohan, “Operations Research ”, Sultan Chand & Sons, 2007.

2. V. Sundaresan, K. S. Ganapathy Subramanian, K. Ganesan, Resource Management Techniques, A. R. Publications, Arpakkam, Nagapattinam Dt. , 2005. (Unit – I & V)

Core XI – Functional Analysis

Semester: IV **Code: P23MA411**
Hrs. / Week: 6 **Credits: 5**

Pre-requisite: Elements of Real Analysis

Objectives of the Course:

To provide students with a strong foundation in functional analysis, focusing on spaces, operators and fundamental theorems. To develop student's skills and confidence in mathematical analysis and proof techniques.

Course Outline:

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–Ortho normal 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.

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 – Application of the formula – Involutions in Banach algebras-The Gelfand-Neumark theorem.

Text Books:

G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Education (India)Private Limited, New Delhi, 1963.

Unit I Chapter 9 § 46-51
Unit II Chapter 10 § 52-59
Unit III Chapter 11 § 60-62
Unit IV Chapter 12 § 64-69

Unit V Chapter 13 § 70-73

References:

1. W.Rudin, Functional Analysis, McGraw Hill Education (India) Private Limited, New Delhi, 1973.
2. B.V. Limaye, Functional Analysis, New Age International,1996.
3. C. Goffman and G. Pedrick, First course in Functional Analysis, Prentice Hall of India, NewDelhi,1987.
4. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, New York, 1978.
5. M. Thamban Nair, Functional Analysis, A First course, Prentice Hall of India, New Delhi, 2002.

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. http://en.wikiepedia.org

Core XII – Differential Geometry

Semester: IV **Code: P23MA412**
Hrs. / Week: 6 **Credits: 5**

Pre-requisite: Linear Algebra concepts and Calculus

Objectives of the Course:

This course introduces space curves and their intrinsic properties of a surface and geodesics. Further the non-intrinsic properties of surface and the differential geometry of surfaces are explored

Course Outline:

Unit-I : Space curves:

Definition of a space curve – Arc length – tangent – normal and binormal – curvature and torsion – contact between curves and surfaces- tangent surface- involutes and evolutes- Intrinsic equations – Fundamental Existence Theorem for space curves- Helies.

Unit-II : Intrinsic properties of a surface:

Definition of a surface – curves on a surface – Surface of revolution – Helicoids – Metric-Direction coefficients – families of curves- Isometric correspondence- Intrinsic properties.

Unit-III : Geodesics:

Geodesics – Canonical geodesic equations – Normal property of geodesics- Existence Theorems – Geodesic parallels – Geodesics curvature- Gauss- Bonnet Theorem – Gaussian curvature-surface of constant curvature.

Unit-IV : Non Intrinsic properties of a surface:

The second fundamental form- Principle curvature – Lines of curvature – Developable - Developable associated with space curves and with curves on surface - Minimal surfaces – Ruled surfaces.

Unit-V : Differential Geometry of Surfaces :

The fundamental equations of surface theory – Parallel surfaces – Fundamental existence theorem for surfaces. Compact surfaces whose points are umbilics- Hilbert's lemma – Compact surface of constant curvature.

Text Books:

T.J. Willmore, An Introduction to Differential Geometry, Oxford University Press, (17th Impression) New Delhi 2002. (Indian Print)

Unit I Chapter 1 § 1 - 9.

Unit II Chapter 2 § 1 - 9.
Unit III Chapter 2 § 10 - 18.
Unit IV Chapter 3 § 1 - 8.
Unit V Chapter 3 § 9 – 11
Chapter 4 § 1 - 4

References:

1. Struik, D.T. Lectures on Classical Differential Geometry, Addison – Wesley, Mass. 1950.
2. Kobayashi. S. and Nomizu. K. Foundations of Differential Geometry, Inter science Publishers, 1963.
3. Wilhelm Klingenberg: A course in Differential Geometry, Graduate Texts in Mathematics, Springer-Verlag 1978.
4. J.A. Thorpe Elementary topics in Differential Geometry, Under- graduate Texts in Mathematics, Springer - Verlag 1979.

Website and e-Learning Source:

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics
3. http://www.opensource.org
4. www.physicsforum.com

Core Project

Semester: IV **Code: P23MA4PJ**

Hrs. / Week: 8 **Credits: 7**

Elective VI – Statistical Data Analysis using R Programming

Semester: IV **Code: P23MA4:P**

Hrs. / Week: 4 **Credits: 3**

Objectives of the Course:

On completion of this course, the learner will

- be able to apply the software R to derive statistical inferences.
- know the different commands and packages available in R.
- identify their applications in different statistical studies.

List of Practicals:

1. Importing and exporting data
2. Graphical display of data using the package ggplot2
3. Performing basic Statistics using the package RCmdr
4. Importing C files in R programming
5. Importing LaTeX files in R programming
6. Discrete and continuous distributions
7. One-way between – Groups ANOVA
8. Two-way between – Groups ANOVA
9. Chi-square test of independent samples
10. Latin Square Design
11. Wilcoxon signed-rank test
12. Mann Whitney U test
13. Kruskal Wallis test
14. Multiple Linear Regression
15. Polynomial Regression
16. Logistic Regression

Reference Books

1. Paul Teetor, R Cookbook, Shroff Publishers & Distributors Pvt. Ltd., 2014
2. Randall Schumacker, Learning Statistics using R, Sage Publication, 1st edition, 2017
3. Jared P. Lander, R for Everyone, Pearson Education, 2nd Edition, 2017
4. Garrett Grolemund, Hands on programming with R, O’Reilly, 1st edition, 2013

Website and e-Learning Source

1. https://www.coursera.org/learn/data-analysis-r
2. https://www.coursera.org/learn/r-programming
3. https://www.r-project.org/
4. https://www.r-project.org/other-docs.html
5. https://www.rstudio.com/
6. https://scholar.harvard.edu/dromney/online-resources-learning-r

PCS - Training for Competitive Examinations

Semester: IV **Code: P23MA4S1**
Hrs. / Week: 4 **Credits: 2**

Objectives of the Course:

On completion of this course, the learner will gain:

1. Mathematical Skills required to clear NET / UGC - CSIR/ SET / TRB Competitive Examinations.
2. Knowledge of General Studies required to clear UPSC / TNPSC Competitive Examinations.

Unit-I: Real Analysis

Problem Solving Techniques in Real Analysis-Problem Solving Techniques in Complex Analysis.

Unit-II: Algebra

Problem Solving Techniques in Abstract Algebra -Problem Solving Techniques in Linear Algebra.

Unit III: Differential Equations

Problem Solving Techniques in Ordinary Differential Equations - Problem Solving Techniques in Partial Differential Equations.

Unit IV:

TNPSC Group I General Studies for Preliminary Examination.

Unit V:

UPSC General Studies for Civil Service Preliminary Examination.

References :

1. Info Study’s Real Analysis by A.P.Singh Info Study Publications
2. Info Study’s Complex Analysis by A.P.Singh Info Study Publications
3. Info Study’s Modern Algebra by A.P.Singh Info Study Publications
4. Info Study’s Linear Algebra by A.P.Singh Info Study Publications
5. Info study’s Differential Equation by Dr. A. P. Singh Info Study Publications
6. Sura’s TNPSC Group-I Preliminary Exam Q-Bank (7 Previous Year's Original Question Papers Included) Book – 2022 by V.V.K. Subburaj.
7. Oswall Books UPSC CSE Prelims 10 Year’s Solved Papers (2013 – 2022), General Studies Paper I.

PG – Non-Major Elective Courses (NMEC)

(Offered to students of other Disciplines)

Sem.	Course	Code	Title	Hr. / Week	Credits	Marks		
						CIA	ESA	Total
I	NMEC I	P23MA2E1	Operations Research for Management	2	2	25	75	100
II	NMEC II	P23MAPE2	Statistics with R Programming	2	2	40	60	100

NMEC I – Operations Research for Management

Semester: II **Code: P23MA2E1**
Hrs. / Week: 4 **Credits: 2**

General objectives:
On completion of this course, the learner will be able

1. to model management problems in such a way that It could be solved mathematically.
2. to understand various methods of operations research to solve business problems.
3. to apply the appropriate methods of operations research to solve the problems in business management.

Unit I

Decision Analysis-Decision making problem – Decision making process – Decision making Environment – Decision under uncertainty – Decision under Risk – Decision – Tree Analysis.

Unit II

Games Theory-Two person zero-Sum Games – The maximin – Minimax Principle-Games without saddle points - Graphic solution of 2xn and mx2 Games.

Unit III

Mixed Strategy Games-Dominance property - Arithmetic method for nxn games – General solution of mxn Rectangular Games using linear programming.

Unit IV

Dynamic Programming – Product Allocation Problem – Cargo – Loading Model – workforce size model.

Unit V

Sequencing problem – processing n jobs through Two machines – processing n jobs through k machines – processing 2 jobs through k machines.

Text Books

1. KantiSwarup, P.K. Gupta, Manmohan, Operations Research, Sultan Chand & Sons, Reprint 2009.(Units I, II, III & V)
2. HamdyA.Taha, Operations Research and Introduction, Seventh Edition, Prentice – Hall of India, New Delhi.,2009.

Units I	Chapter 16§ 16.1 – 16.7
Unit II	Chapter 17§ 17.1 – 17.6
Unit III	Chapter 17§ 17.7 – 17.9
Unit IV	Chapter 10§ 10.3.1, 10.3.2
Unit V	Chapter 12§ 12.1 – 12.6

NMEC II - Statistics with R Programming

Semester: III **Code: P23MAPE2**
Hrs. / Week: 3 **Credits: 2**

Objectives of the Course:

On completion of this course, the learner will

1. be able to apply the software R to derive statistical inferences.
2. know the different commands and packages available in R and their applications in different statistical studies.

List of Experiments:

1. Calculation of Measures of Central Tendency
2. Calculation of Measures of Dispersion
3. Importing and Exporting data
4. Graphical display of data
5. Calculation of Statistical Parameters (Mean, Variance and Standard Deviation) of some Discrete and Continuous random variables.
6. Calculation of Coefficient of Variation
7. Calculation of Measures of Skewness
8. Calculation of Correlation Coefficient
9. Calculation of Rank Correlation
10. Finding Regression lines
11. Testing of Hypotheses using One sample t- test
12. Testing of Hypotheses using Independent sample t-test
13. Testing of Hypotheses using Dependent sample t-test
14. Testing of Hypotheses using One-way between – Groups ANOVA
15. Testing of Hypotheses using Two-way between – Groups ANOVA

References:

1. Mark Gardener, Beginning R – The statistical Programming Language, Wiley Publications, 2015
2. W.John Braun and Duncan J. Murdoch, A First Course in Statistical Programming with R, Cambridge University Press, 2007.

Website and e-Learning Source

1. https://www.coursera.org/learn/data-analysis-r
2. https://www.coursera.org/learn/r-programming

PG – Extra Credit Courses

Course	Code	Title	Hr. / Week	Credits	Marks		
					CIA	ESA	Total
I	PX3MA3SA	Fuzzy Sets and Their Applications	-	2	-	100	100
II	PX3MA3SB	Stochastic Processes	-	2	-	100	100
III	PX3MA4SC	Wavelet Theory	-	2	-	100	100
IV	PX3MA4SD	Mathematical Physics	-	2		100	100

Extra Credit Course I – Fuzzy Set Theory and Their Applications

Code : **Credits: 2**

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.

Course Outline

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 : 1.4, - 1.6
	Chapter 2 : 2.1-2.4,2.6
Unit II	Chapter 3 : 3.3,3.4
	Chapter 4 : 4.1- 4.3
Unit III	Chapter 5 : 5.1-5.4

Unit IV Chapter 6 : 6.1-6.3

Unit V Chapter 8 : 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.

Website and e-Learning Source

1. https://nptel.ac.in/courses/111/102/111102130/
2. https://mooc.es/course/introduction-to-fuzzy-set-theory-arithmetic-and-logic/

Extra Credit Course II - Stochastic Processes

Code: **Credits : 2**

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.

Course Outline

Unit I Stochastic Processes

Some notions - Specifications of stochastic processes- Stationary processes- Markov Chains – Definition and examples-Higher transition probabilities.

Unit II Markov Chains

Generalization of Independent Bernoulli trials- Sequences of chain –Dependent trails - Classification of states and chains - determination of higher transition probabilities- Stability of Markov system - Graph theoretic approach - Markov chain with denumerable number of states.

Unit III Markov Process with Discrete State Space

Poisson process: Poisson process and related distributions – Generalizations of Poisson process – Birth and death process – Markov process with discrete state space (Continuous time Markov chain).

Unit IV Renewal Processes and Theory

Renewal Processes - Renewal Processes with continuous time – Renewal equation –Wald's equation: stopping time- Renewal theorems.

Unit V Stochastic Processes in Queueing

Queuing process systems: General concepts- The queuing model M/M/1: Steady state behavior – Transient behavior of M/M/1 model.

Text Book:

1. Medhi J. (1994), Stochastic Processes, Second Edition, Wiley Eastern Ltd New Delhi.

Unit I	Chapter 2: 2.1 - 2.3 & Chapter 3: 3.1, 3.2
Unit II	Chapter 3: 3.3 - 3.8
Unit III	Chapter 4: 4.1 - 4.5

Unit IV Chapter 6: 6.1 - 6.5

Unit V Chapter 10: 10.1 - 10.3

References

1. Samuel Karlin & Howard M.Taylor (1981.), A First Course in Stochastic Processes, Academic Press.
2. Samuel Karlin & Howard M.Taylor (1981), A Second Course in Stochastic Processes, Academic Press.
3. Basu A. K (2003), Introduction to Stochastic Process, Narosa Publishing House, New Delhi.
4. Richard Bron Son, Govindasami Naadimuthu (2004), Operations Research Second Edition, Tata Mc.Graw Hill Publishing Company Ltd., New Delhi. (for Queuing Theory)
5. Sheldon M. Ross, Stochastic Processes. 2nd Edition John Wiley and Sons, Inc.2004.
6. Srinivasan SK. & Medhi J. (1978), Stochastic Process, Second Edition, Tata Mc Graw-Hill Publishing Company ltd.
7. U. Narayanan Bhat, Elements of Applied Stochastic Processes, John Wiley & Sons, 1984.

Extra Credit Course III – Wavelet Theory

Code: **Credits : 2**

General Objectives

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 – Mathematical Physics

Code: **Credits : 2**

General Objectives

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).