ANNEXURE I

Krishna Kanta Handiqui State Open University
Curriculum Structure in
Master of Science (Mathematics)

Credit Distribution for Master of Science (Mathematics)

SL No	Nature of Courses	Total no. of Courses	Credit	Total Credits
1	DSC (Discipline Specific Core)	12	4	48
2	DSE (Discipline Specific Elective)	04	4	16
3	AEC (Ability Enhancement Course)	02	4	08
4	VAC (Value Added Course)	02	2	04
5	Seminar	01	4	04
6	Project/Dissertation	01	8	08
	Total	22		**88**

Course Distribution for Master of Science (Mathematics)

Semester	DSC	DSE	AEC	VAC	Dissertation/ Seminar	Semester wise credits
I	DSC 1, DSC 2, DSC 3	DSE 1	AEC 1	VAC 1		22
II	DSC 4, DSC 5, DSC 6	DSE 2		VAC 2	Seminar	22
III	DSC 7, DSC 8, DSC 9	DSE 3	AEC 2			20

IV	DSC 10, DSC 11, DSC 12	DSE 4			Project/Dissertation	24
Total Credits	48	16	08	04	12	**88**

Semester-wise Course and Credit Distribution

Semester	**DSC (Core)** (12 Courses, Credit 4 each)	**DSE** (4 Courses, Credit 4 each)	**AEC** (2 Courses, Credit 4 each)	**VAC** (2 Courses, Credit 2 each)	**Dissertation/ Seminar** (Seminar: 4 Credit, Project: 8 Credit)	**Total Credits**
I	Abstract Algebra Differential Equations Real Analysis	Computer Programming using C	AEC 1	VAC 1		**22**
II	Complex Analysis Introduction to Topology Linear Algebra	Operations Research		VAC 2	Seminar	**22**
III	Functional Analysis Classical Mechanics Integral Equations and Calculus of Variation	Measure theory and Integration OR Fluid Dynamics	AEC 2			**20**
IV	Numerical Analysis and Computation Number Theory Graph Theory	Differential Geometry OR Fuzzy Sets and Applications			Project/ Dissertation	**24**
Total Credit	**48**	**16**	**8**	**4**	**12**	**88**

Marks Distribution of Courses for Master of Science (Mathematics)

Course Code	Semester	Course	Whether DSC/DSE/AEC/VAC	Marks	Credit
	1st	Abstract Algebra	DSC	30F+70S	4
		Differential Equations	DSC	30F+70S	4
		Real Analysis	DSC	30F+70S	4
		Computer Programming in C	DSE	20F+30P+50S	4
		AEC	AEC	30F+70S	4
		VAC	VAC	30F+70S	2
	2nd	Complex Analysis	DSC	30F+70S	4
		Introduction to Topology	DSC	30F+70S	4
		Linear Algebra	DSC	30F+70S	4
		Operation Research	DSE	30F+70S	4
		VAC	VAC	30F+70S	2
		Seminar	Dissertation/ Seminar	100	4
	3rd	Functional Analysis	DSC	30F+70S	4
		Classical Mechanics	DSC	30F+70S	4
		Integral Equations and Calculus of Variation	DSC	30F+70S	4
		(Choose any one) Measure theory and Integration Fluid Dynamics	DSE	30F+70S	4
		AEC	AEC	30F+70S	4
	4th	Numerical Analysis and Computation	DSC	30F+70S	4
		Number Theory	DSC	30F+70S	4
		Graph Theory	DSC	30F+70S	4
		(Choose any one) Differential Geometry Fuzzy Sets and Applications	DSE	30F+70S 30F+70S	4
		Major Project		200	8
					88

N.B.:

F = Formative Assessment (i.e., Internal Assessment)
P = Practical (Summative Assessment)
S = Summative Assessment (i.e., End Semester Examination)

1 credit = 30 hours of learning

4 credits=30 × 4=120 hours of learning

ANNEXURE II
Master of Science (Mathematics)

DETAILED COURSE WISE SYLLABUS
Syllabus of Discipline Specific Core (DSC) Courses

SEMESTER I: Abstract Algebra

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- study Group action and permutations representations,
- Cayley's theorem, class equation, the fundamental theorem of finitely generated abelian group, p-groups, solvable
- groups, polynomial rings over a field, Subfield and prime fields, extensions of fields.

Course Outcomes: After successful completion of this course, the learner will able to

- Describe the Group theoretic notions of class equation and the related results.
- Discuss three important classes of Ring structures, viz., the principal ideal Domain, Euclidean domain and the unique factorization domain.
- Familiarize with group action, groups acting on themselves by conjugation.
- Understand direct products, the fundamental theorem of finitely generated abelian group, p-groups, solvable groups.
- Familiarize with Eisenstein's criterion for irreducibility of $(x) \in [x]$ over Q, roots of polynomials.
- Familiarize with subfield and prime fields.

Unit 1: Introduction to Groups

Groups, subgroup, Cyclic groups

Unit 2: Lagrange's Theorem, **Normalsubgroup and Quotient Groups**
Cosets, Lagrange's Theorem,normal subgroup, Quotient Groups

Unit 3: Permutation Groups
Permutation Groups, Alternating group A_n

Unit 4: Homomorhismsof Groups

Homomorphism of groups,Types of Homomorphism, Properties of Homomorphism

Unit 5: Direct Products of Groups and Finite Abelian Groups

External direct products of Groups, Internal Direct products, Structure of Finite Abelian

groups

Unit 6: Group Series and Structure

Normal and Subnormal series, Composition Series, Zassenhaus Lemma, Schreier's refinement theorem, Jordan-Holder theorem, Commutator subgroup, Solvable Groups, Nilpotent groups

Unit 7: Class Equation and Cauchy's Theorem

Class equation, Cauchy's theorem, Sylow p-subgroups and its applications

Unit 8: Group Actions and Sylow Theorems

Group Actions, Sylow's theorem, Application of Sylow's theorem

Unit 9: Rings, Integral Domains and Fields

Rings, Subrings, Integral Domains, Fields, Characteristic of Rings, Ideals

Unit 10: Factor Rings and Ring Homomorphism

Factor Ring, Ring Homomorphism, Isomorphism Theorems

Unit 11: Polynomial Rings

Polynomial Rings, Irreducible Polynomials, Irreducibility Tests, Structure of Finite fields

Unit 12: Factorization in Integral Domains and Field Extensions

Associates, Irreducible, and primes, Principal Ideal Domains, Unique Factorization Domains, Euclidean Domains, Field Extensions

Unit 13: Splitting Field

Concept of splitting field, Examples of splitting field

Unit 14: Normal Extensions and Perfect Fields

Normal extensions, Perfect fields, Finite fields, Primitive elements, algebraically closed fields, Automorphisms of extensions

Unit 15: Galois Groups and Galois Extensions

Galois Groups, Galois Extensions

Suggested Readings:

1. Gallian, J. *A. Contemporary Abstract Algebra*. 9th edition. Cengage Learning, 2015.
2. Lang, S. *Algebra*. 3rd edition, Springer 2012.
3. Herstein, I. N. *Topics in Algebra*. 2ndedition. John Wiley and Sons, 2006.

4. Bhattacharya, P. B. Jain, S. K. and Nagpaul, S. R. *Basic Abstract Algebra.* 2nd edition, Cambridge University Press, 2003.
5. Khanna, V. K. and Bhammbri, S. K. *A Course in Abstract Algebra*. Vikas Publishing house, 1999.
6. Cohn, P. M. *Algebra.* Vols. I & II, John Wiley & Sons, 1991.
7. Luther, S. and Passi, I. B. S. *Algebra.* Vol. I-Groups, Vol. II-Rings, Narosa Publishing House (Vol. I – 1996, Vol. II –1990).
8. Hungerford, T. W., Algebra. (1974). Springer-Verlag. New York.
9.D.S.Dummit and R.M.Foote , Abstract Algebra(3rd Edition), Wiley,2011
10. N. Jacobson, *Basic Algebra I* (3rd edition), Hindustan Publishing corporation, New Delhi, 2002.
11. J. B. Fraleigh ,*A First Course in Abstract Algebra* (4th edition), Narosa Publishing House, New Delhi, 2002.
12.J.J. Rotman:*An Introduction to the theory of groups*,Springer,1994.

SEMESTER I: Differential Equations

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Outcomes: After successful completion of this course, the learner will able to

- study Initial Value Problems (IVP),
- second order differential equations and few methods to solve Partial Differential Equations (PDE).

Course Outcomes: After successful completion of this course, the learner will able to

- Solve IVP.
- Solve elliptic, parabolic and hyperbolic differential equations.
- Monge's method to solve non-linear PDEs.
- Reducing the PDEs into its canonical forms.
- Solve PDE by separation of variables method.
- Apply various power series methods to obtain series solutions of differential equations.
- Determine the solutions of linear PDE's of second and higher order with constant coefficients, classify second order PDE's, solve standard PDE using separation of variable method and reduction to canonical form.
- Solve the first-order linear and non-linear PDE's by using Lagrange's, Charpit's
  method and Jacobi's method respectively.

Unit 1: Introduction to differential Equations

Definition and Classification of differential equations, order and degree of differential equation, Initial value problem (IVP) and boundary value problems (BVPs)

Unit 2: Differential Equations of First order and First Degree

Variable Separable Method, Homogeneous Differential Equation, Linear Differential Equation, Bernoulli's equation

Unit 3: Exact Differential Equation of first order and first degree

Exact differential Equations, Equation reducible to exact equations

Unit 4: Existence and Uniqueness

Well posed problems, Lipschitz condition, existence and uniqueness theorem for first order equations. Picard's method, Initial value problems for second order equations; existence theorem; uniqueness theorem; linear dependence and independence of solutions; Wronskian

Unit 5: Higher Order Linear Differential Equations
Homogeneous and non-homogeneous linear Differential Equations, Method of undetermined coefficients, Method of variation of parameter

Unit 6: Orthogonality and Independence in ODES

Orthogonality of functions, Orthonormal set of functions, Singular solutions of first order ODEs

Unit 7: First order Linear partial Differential Equations

Formulation and origin of First order PDEs, Solution of a PDE, Solutions to linear PDEs of first order

Unit 8: Second order Partial Differential Equations with constant coefficients

Partial Differential Equations of Second Order: Liner partial differential equations of second order with constant co-efficient, Characteristic curves of second order equations, Reduction to canonical forms, Separation of variables, Solutions of nonlinear equations of the second order by Monge's method

Unit 9: Higher Order linear PDEs

Introduction to higher order PDEs, Method of separation of variables, Canonical form and reduction to canonical forms

Unit 10: First order Nonlinear PDE-I

Cauchy's Method of Characteristic**,**Charpit's method and Jacobi method, special types of first order PDEs,

Unit 11: Nonlinear First Order PDE-II

Complete Integrals, Envelopes, Characteristics,

Unit 12: Elliptic Differential Equations

Elliptic differential equations. Occurrence and detailed study of the Laplace and the Poisson equation. Maximum principle and applications, green's functions and properties.

Unit 13: Parabolic Differential Equations

Parabolic differential equations. Occurrence and detailed study of the heat equation. Maximum principle. Solutions of IVPs for heat conduction equation. Green's function for heat equation, Duhamel's principle.

Unit 14: Hyperbolic Differential Equations

Hyperbolic differential equations. Occurrence and detailed study of the wave equation. Solution of three-dimensional wave equation. Method of descent and Duhamel's principle. Solutions of equations in bounded

Suggested Readings:

1. Simmons, G. F. *Differential Equations with Applications and Historical Notes*. 2nd edition, Tata McGraw Hill, New Delhi, 2016.
2. Evans, L. C. *Partial Differential Equations*. 2nd edition, The Orient Blackswan, 2014.
3. Lebedev, N. N. *Special Functions and Their Applications*. Revised, Courier Corporation, 2012.
4. Ross, S. L. *Differential Equations*. 3rd edition, Wiley India, 2007.
5. Sneddon, I. N. *Elements of Partial Differential Equations*. Dover Publications, 2006.
6. Bell, W. W. *Special Functions for Scientists and Engineers*. Courier Corporation, 2004.
7. Raisinghania, M. D. *Advanced Differential Equations*. S. Chand & Company Ltd., New Delhi, 2001.
8. Reid, W. T. *Ordinary Differential Equations*. John Wiley and Sons, New York, 1971.
9. E.A. Coddington, *An Introduction to Ordinary Differential Equations*, Dover Publications
10. T. Myint-U, *Ordinary Differential Equations*, Elsevier, North-Holland, 1978.
11. Bhamra, K. S. (2010), *Partial Differential Equations*, PHI Learning Pvt. Ltd.

SEMESTER I: Real Analysis

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- introduce the basic concept of uniform convergence of sequence and series of functions, power series,
- Describe the properties of the Real numbers
- Analyze the properties of advanced differentiation and Integration of real valued functions in one or multiple variables

Course Outcomes: After successful completion of this course, the learner will able to

- Use of uniform convergence of sequence and series of functions
- Use of exponential and logarithmic functions, trigonometric functions, Fourier series to solve problems
- Use of bounded variations, Reimann-Stieltjes integral and their applications
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences. To calculate the limit superior, limit inferior of sequences and limit of a bounded sequence.
- Recognize bounded variation, total variation, directional derivatives, partial derivative and derivative as a linear transformation.

UNIT -1: Real Number System-I

Field axioms, some properties of real numbers, Absolute value or modulus of real number, Bounded and unbounded subsets of real numbers, least upper bound or supremum, Greatest lower bound or infimum, Some properties of supremum and infimum, Completeness axiom, The set of real number as a complete ordered field, Archimedean property of real numbers, The denseness property of the real number system

UNIT -2: Real Number System-II

Neighbourhood of a point, Limit points of a set, Bolzano Weierstrass theorem, Interior of a set, Open sets, Closed sets, Closure of a set, Countability of sets, Dedekind's property of real numbers

UNIT-3: **Sequence**

Sequence, Subsequence, Bounded sequences, Convergent sequences, Divergent Sequences, Algebra of convergent sequences, Monotonic sequences, Limit point of a sequence, Cauchy's sequences, Cauchy's general principle of convergence, Limit superior and limit inferior of a sequence, Nested interval theorem or Cantor's intersection theorem

Unit-4: Infinite Series-I
Convergent and divergent series, Cauchy's general principle of convergence for series, The auxiliary Series $\sum\left(\frac{1}{n^p}\right)$
Unit-5: **Infinite Series-II**
Comparison test, Cauchy's root test, D'Alembert's ratio test, Cauchy's condensation test, Raabe's test, Logarithmic test, De Morgan's test and Bertrand's test, Gauss's test, Cauchy Maclaurin's integral test, Alternating series, Alternating series test (Leibnitz's test), Absolute convergence and conditional convergence

Unit-6: Power Series
Power series, Radius of convergence, Uniqueness of power series, Properties of power series

UNIT-7: Limits of Functions
Limit, Algebra of limits of functions, Right hand and left-hand limits, Infinite limit,

Unit -8: Continuous Functions

Cauchy's definition of continuity, Types of discontinuity, Algebra of continuous functions, Properties of continuous functions, Uniform continuity

UNIT-9: Differentiable Functions
Derivative of a point, Derivative of a function, A necessary condition for the existence of finite derivative, Algebra of derivatives, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, Taylor's series, Maclaurin's series

Unit 10: Functions of Several Variables
Structure of R^n,Limit,continuity of functions of R^n to R,Directional derivatives and Partial derivatives,

UNIT-11: The Riemann Integral
Partitions and Riemann sums, Upper and lower Riemann integrals, Riemann integrability, Riemann's necessary band sufficient conditions for R-integrability, Some classes of integrable functions, Fundamental theorem of integral calculus

UNIT-12: **The Riemann-Stieltjes integral**
A generalization of the Riemann integral, Partitions, Lower and upper Riemann-Stieltjes integrals, The Riemann-Stieltjes integral, The RS-integrals as a limit of sums, Some classes of RS-integrable functions, A relation between R-integral and RS-integral

UNIT-13: **Uniform convergence of sequences and series**
Uniform convergence, Cauchy's general principle of uniform convergence, Tests for uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation

UNIT-14: **Convergence of Improper integrals**

Convergence of improper integrals, Tests for convergence of improper integrals of the first kind, Absolute convergence, Tests for convergence of improper integrals of the second kind

Suggested Readings:

1. Walter, R. *Principles of Mathematical Analysis*. 3rdedition, McGraw-Hill, 2017.
2. Terence T. *Analysis II*. Hindustan Book Agency, 2009.
3. Malik, S. C. and Arora, S. *Mathematical Analysis*. 2nd edition reprint. New Age International Publishers 2005.
4. Apostol, T. M. *Mathematical Analysis*. 2nd edition. *Wesley Publishing Co.* 2002.
5. Somasundram, D. and Chaudhary, B. *A First Course in Mathematical Analysis*. Narosa Publishing House, 1996.
6. Royden, H. L. *Real Analysis,* Macmillan Pub. Co., Inc. 4th edition, New York, 1993.
7. Bartle, R. G., Sherbert, D. R. (2011). *Introduction to real analysis*. Hoboken, NJ: Wiley.
8. Narayan, S., Raisinghania, M.D. *Elements of Real Analysis*.S. Chand & Company Pvt.Ltd.2015.

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SEMESTER II: Complex Analysis

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- familiarize the learner with complex function theory, analytic functions theory, the concept of index and Cauchy's theorems, integral formulas, singularities and contour integrations and finally provide a glimpse of maximum principle and Schwarz' lemma.

Course Outcomes: After successful completion of this course, the learner will able to

- understand analytic function as a mapping on the plane, Mobius transformation and branch of logarithm.
- understand Cauchy's theorems and integral formulas on open subsets of the plane.
- understand how to count the number of zeros of analytic function giving rise to open mapping theorem and Goursat theorem as a converse of Cauchy's theorem.
- know about the kind of singularities of meromorphic functions which helps in residue theory and contour integrations.
- handle integration of meromorphic function with zeros and poles leading to the argument principle and Rouche's theorem.
- Analyze the concept of differentiability, analyticity, Cauchy-Riemann equations and harmonic functions.
- Understand the concept of bilinear transformation and conformal mapping.

Unit 1: Functions of a complex variable
Functions of a complex number, Continuity and differentiability of complex function

Unit 2: Analytic Functions
Analytical function, Conjugate function, Harmonic function,

Unit 3: Cauchy -Riemann Equations
Cauchy-Riemann equations, Polar form of Cauchy-Riemann equations, Construction of analytical functions

Unit 4: Power Series
Power series, Absolute Convergence, Some special tests for convergence of power series, Radius of convergence of power series

Unit 5: Conformal Representation

Definitions and examples of Conformal transformation, Some general transformation, Bilinear transformations, their properties and classifications

Unit 6: Complex integration
Definite integrals, Contours, Contour integrals, Antiderivative, Cauchy-Goursat theorem

Unit 7: Cauchy Integral Formula

Cauchy's integral formula, Extended Cauchy integral formula, Higher order derivatives in the context of Cauchy's Formula

Unit 8: Liouville's Theorem and Fundamental Theorem of Algebra

Liouville's theorem, The fundamental theorem of algebra

Unit 9: Taylor and Laurent Series
Taylor series, Laurent series

Unit 10: Zeros and Singular point
Zeros of Analytical functions, Singular points, Different types of singular point

Unit 11: Poles and Singularities
Poles, Singularities, Types of singularities

Unit 12:The calculus of Residue
Residue, Cauchy's residue theorem, Residue at infinity, Residue at poles, Zeros and poles

Unit 13: Application of Residues-I
Evaluation of improper integrals, Integrals involving sines and cosines

Unit 14: Application of Residues-II
Argument principle, Rouche's theorem

Suggested Readings:

1. Saff, E. B. and Snider, A. D. *Fundamentals of Complex Analysis with Applications to Engineering and Sciences*. Pearson Education, 2014.
2. Conway, J. B. Functions of One Complex Variable, Springer, 2012.
3. Mathews, J. H. and Howell, R. W. *Complex Analysis for Mathematics and Engineering*. Jones & Bartlett Publishers,2012.
4. Brown, J. B. and Churchill, R. V. *Complex Variables and Applications*. 8th edition, Tata McGraw-Hill Education, 2009.
5. Ponnusamy, S. *Foundations of Complex Analysis.* Alpha Science International, 2005.
6. Copson, E. T. *Theory of Functions of Complex Variables*. Oxford University Press, 1970.
7.L.V. Ahlfors, *Complex Analysis*, Mc Graw Hill Co., Indian Edition, 2017.
8. J.B. Conway, *Functions of One Complex Variable*, Second Edition, Narosa, New Delhi,1996.
9. T.W. Gamelin, *Complex Analysis*, Springer, 2001.
10.L. Hahn, B. Epstein*, Classical Complex Analysis*, Jones and Bartlett, 1996.
11.M. Spiegel: *Complex variables*, Schaum'souline 2017, second edition.

SEMESTER II: Introduction to Topology

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- introduce basic concepts of point set topology, basis and subbasis for a topology and order topology.
- study continuity, homeomorphisms, open and closed maps, product and box topologies and introduce notions of connectedness, path connectedness, local connectedness, local path connectedness, convergence, nets, countability axioms and compactness of spaces.
- introduce the basic concept of product topology, continuity and related concepts, product topology and box topology; Metric topology, Quotient topology, Connected spaces, local path connectedness etc.

Course Outcomes: After successful completion of this course, the learner will able to

- determine interior, closure, boundary, limit points of subsets and basis and subbasis of topological spaces.
- check whether a collection of subsets is a basis for a given topological spaces or not, and determine the topology generated by a given basis.
- identify the continuous maps between two spaces and maps from a space into product space and determine common topological property of given two spaces.
- determine the connectedness and path connectedness of the product of an arbitrary family of spaces.
- find Hausdorff spaces using the concept of net in topological spaces and learn about 1st and 2nd countable spaces, separable and Lindelöf spaces.
- learn Bolzano−Weierstrass property of a space and prove Tychonoff theorem.

Unit 1: Closed and Open Set in R

Real line, open and closed interval, Neighbourhood of a point, properties of a neighbourhoods, Upper bound, Lower bound, Supremum, Infimum, Bounded below, Unbounded, Limit point, closed set, open set, Derived set, Bolzano weierstrass Theorem

Unit 2: Metric Space-I

Definitions, Examples and Theorems –Open sets, Accumulation points, Derived Set, Closed sets, Closure. Dense subsets.

Unit 3: Metric Space-II

Neighborhoods. Interior, exterior and boundary. Points, Convergent sequences, Coarser and finer topologies. Metrics on Products, Incomplete and Complete Metric Spaces

Unit 4: Topological Spaces
Topology, T-open sets, Weaker and Stronger topology, Indiscrete and discrete topology, Co-finite topology, Usual topology, Open sets, Closed sets, Neighbourhood, Closure, Interior, Limit point

Unit 5: Bases, Sub-bases and Countability
Base, Sub-base, Local base, first countable, second countable theorem

Unit 6: Continuous Functions
Continuity, sequentially continuous, Homeomorphism, Topological property, open and closed maps, Uniform continuity

Unit 7: Separation Axioms-I
T_0, T_1, T_2Spaces, normal spaces, Housdorff Spaces, Regular Spaces

Unit 8: Separation Axioms-II
T_3, T_4-Spaces, completely regular Spaces, Tychnoff Space, completely normal T_0 Space

Unit 9: Compactness-I
Cover, Open Cover, finite sub-cover, reducible, compact sets, finite intersection property, locally compact, Bolzano Weirerstrass property

Unit 10: Compactness-II
Sequentially compact, Compactness for continuous images, Compactness for metric space

Unit 11: Completeness of a metric space
Cauchy sequence, Bair's category, Contraction map, Cantor's intersection theorem, Bair's category theorem, Ascoli's theorem

Unit 12: Connectedness in topological spaces
Separated sets, Disconnectedness, totally disconnected, Maximal connected set, Components, Path connectedness, Local connectedness

Unit 13: Quotient and Product topology

Product topology, Projection map, Quotient spaces

Unit 14: Metrization
Metrization, Uryshohn'smetrization theorem

Suggested Readings:
1. Joshi, K. D. *Introduction to General Topology*. 2nd edition, New Age International Private Limited, 2017.
2. Munkres, J. R. *Toplogy*. Pearson Education, 2017.
3. Simmons, G. F. *Introduction to Topology and Modern Analysis*. Tata McGraw-Hill Education, 2016.

4. Pervin, W. J. *Foundations of General Topology*. Academic Press, 2014.
5. Singh, T. B. *Elements of Topology*. CRC Press, Taylor Francis, 2013.
6. G.E. Bredon, Topology and Geometry, Springer, 2014.
7. J. Dugundji, *Topology*, Allyn and Bacon Inc., Boston, 1978.
8. J.L. Kelley, *General Topology*, Dover Publications, 2017.
9. T.B. Singh, *Elements of Topology*, CRC Press, Taylor & Francis, 2013. [6] S. Willard, General Topology, Dover Publications, 2004.
10. J. R. Munkres, *Topology:a first course* , Prentice-Hall of India Ltd., New Delhi, 2000
11. J. L. Kelley, *General Topology*, Springer Verlag, New York, 1990.
12. K.D. Joshi, *Introduction to General Topology*, Wiley Eastern Ltd., 1983.
13. Crump W. Baker, *Introduction to Topology*, Wm C. Brown Publisher, 1991.
14. M.J. Mansfield, *Introduction to Topology*, D. Van Nostrand Co. Inc. Princeton, N.J., 1963.
15. B. Mendelson, *Introduction to Topology*, Allyn & Bacon Inc., 1962.
16. Seymour Lipschutz, *General Toplogy*, Schaum's Outline Series, 1981

SEMESTER II: Linear Algebra

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A:**30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- introduce the basic concept of matrix of a linear operator, eigen values and eigen vectors, diagonalization, Jordan canonical form, Bilinear form, symmetric form, Hermitian form, orthogonality,

Course Outcomes: After successful completion of this course, the learner will able to

- Learn about eigen values and eigen vectors of a linear operator and a matrix, learn about thediagonalization of a matrix and find the Jordan canonical form of a matrix.
- Describe the concepts of the term's basis, dimension, and apply these concepts to various vector spaces and subspaces**.**
- Use the concept of linear transformations, matrix representation and change of basis, including kernel, range.
- Understand the notion of bilinear forms, triangularization and primary decomposition theorem
- Compute inner products and determine orthogonality on vector spaces, applying Gram-Schmidt orthogonalization process to find the orthonormal basis.

Unit 1: Vector Spaces and Subspaces
Vector space, Subspace, Linear combination, Linear span, Linear Sum, Direct Sum, Complimentary subspaces, Disjoint spaces, Quotient space

Unit 2: Linear Dependence
Zero vector, operations on vectors, Vectors in C^n,Vectors in R^n,Unit vector, Orthogonality of two vectors, Linear dependence of vector, Linear independence of vector

Unit 3: Basis and Dimension
Basis, finitely generated spaces, Dimension of vector space, Rank of a matrix, Existence theorem

Unit 4: Linear Transformation
Transformation, Linear transformation, Isomorphism, Range space of linear transformation, Nullity and rank, Singular and non-singular transformation

Unit 5: Matrix Representation of a linear transformation
Co-ordinate vector, Matrix representation of a transformation, Matrix representation of a linear operator, Change of Basis, Similar matrices, Determination of a linear transformation, Similarity of linear map

Unit 6: Linear Functionals and the dual spaces
Linear functional, Dual space, Dual basis, Natural mapping and Reflexivity, Transpose

of a linear map, Annihilator, Adjoint of an operator

Unit 7: Bilinear forms and Quadratic forms
Bilinear form, Symmetric form, Antisymmetric form, Quadratic matrix, Quadratic forms, Matrix representation of bilinear form

Unit 8: Projection and Invariance
Idempotent and Nilpotent operators, Invariance, Reducibility, Projection

Unit 9: Canonical Form-I
Diagonal Form, Triangular Form, Nilpotent Transformation

Unit 10: Canonical Form-II
Jordan Canonical Form, Rational Canonical Form

Unit 11: Inner Product Spaces-I
Inner product, Norm, Orthogonality, Angle, Invariant

Unit 12: Inner product Spaces-II
Normed vector space, Complete orthonormal set, Self-adjoint operator, Bessel's inequality, Gram Schmidt orthogonalization process

Unit 13: Eigen Values and Eigen Vectors-I
Polynomial of matrices and linear operators, Eigen value and Eigen Vector, Matrix Polynomial, Characteristic subspace of a matrix, Eigenspace,

Unit 14: Eigen Values and Eigen Vectors-II
Minimal polynomial of a linear operator, Diagonalization of a linear operator, Diagonalizable matrix, Spectrum

Suggested Readings:

1. Hoffman, K. and Kunze, R. *Linear Algebra*. 2nd edition, Pearson India, 2015.
2. Axler, S. *Linear Algebra Done Right*. 2nd edition, Springer-Verlag, 2014.
3. Lang, S. *Linear Algebra*. 3rd edition, Springer-Verlag, New York, 2013.
4. Lipschutz, S. and Lipson, M. *Linear Algebra*. 3rd edition, Tata McGraw-Hill, 2005.
5. Friedberg, S. H., Insel, A. J. and Spence, L. E. *Linear Algebra*. 4th edition, 2002

SEMESTER III: Functional Analysis

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- introduce the basic concept of topological algebraic structures namely normed linear spaces, Banach spaces, inner product spaces and Hilbert spaces.
- introduce the basic idea of continuous linear transformations between normed linear spaces, Hahn Banach theorem which allows extension of a bounded linear functional from a subspace of a normed space to the whole space.
- introduce Open mapping theorem, Closed Graph theorem and uniform boundedness theorem

Course Outcomes: After successful completion of this course, the learner will able to

- verify the requirements of a norm, completeness with respect to a norm, relation between compactness and dimension of a space, check boundedness of a linear operator and relate to continuity, convergence of operators by using a suitable norm, compute the dual spaces.
- distinguish between Banach spaces and Hilbert spaces, decompose a Hilbert space in terms of orthogonal complements, check totality of orthonormal sets and sequences, represent a bounded linear functional in terms of inner product, classify operators into self-adjoint, unitary and normal operators.

Unit -1: Normed linear Space and relate theorems
Normed linear space and its properties

Unit -2: Banach Space
Inequalities, Examples of Banach Space, Factor Space, Conjugate Space, Conjugate space $C[a, b]$

Unit-3: Bounded Linear Operators
Definitions, Examples and Basic properties, Space of Bounded linear operators, Equivalent Norms

Unit-4: Bounded Linear Functionals
Definitions, Examples and Basic properties

Unit -5: Uniform Boundedness Theorem
Uniform boundedness theorem and some of its consequences

Unit -6: Open mapping theorem
Open mapping Theorem and its consequences

Unit -7: Closed graph theorems

Closed graph theorem and its consequences

Unit -8: Hilbert Space –I
Inner product, Inner product in a normed space, Orthonormal Vectors, Bessel's inequality, Hilbert space

Unit -9: Hilbert Space-II
Orthogonality of Vectors, Orthogonal Complements and Projection Theorem, Orthonormal sets, Complete Orthonormal Sets,A representation theorem on Hilbert space,Reflexivity of Hilbert space

Unit -10: The L^p Space
Properties of L^p Space, Relations between L^p Spaces, Convergence in L^p Space

Unit -11: Weak Convergence and $Weak^*$ Convergence
Weak convergence in Normed Space, Convergence of Sequences of Operators, Weak convergence in Hilbert space, Weak Compactness in Hilbert Space

Unit-12: Functionals and Operators on Hilbert Space
Adjoint of an Operator, Self-adjoint Operator, Positive Operator, Normal and Unitary Operators, Orthogonal Projection

Unit-13: Finite-dimensional Spectral theory
Eigenvalues of a Linear Operator, Eigen vectors, Matrix of an operator, The Spectral theorem

Unit-14: Fixed point theorem and its application on the space of Continuous functions
Fixed point theorem, Application of fixed-point theorem

Suggested Readings:

1. W. Rudin, *Functional Analysis*, McGraw Hill Education, 2017
2. B. V. Limaye, *Functional Analysis*, Willy Eastern Ltd., 1991.
3. C.Goffman and G. Pedrick, *First course in Functional Analysis*, Prentice-Hall of India Pvt. Ltd, New Delhi,1974.
4.G. Bachman and L. Narici, *Functional Analysis*, Dover Publications, 2000.
5.R. Bhatia, *Notes on Functional Analysis*, Hindustan Book Agency, India, 2009.
6.E. Kreyszig, Introductory *Functional Analysis with Applications*, John Wiley & Sons, India, 2006. 7.M. Schechter, *Principles of Functional Analysis*, Second Edition, American Mathematical Society,2001
8.C. Goffman and G. Pedrick: *First Course in Functional Analysis*, Prentice Hall of India, New Delhi,1987.

SEMESTER III: Classical Mechanics

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A:**30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- Comprehend and apply conservation principles governing mechanics, including conservation of linear momentum, angular momentum, and energy
- Understand and apply the Hamiltonian formulation in dynamics, including generalized momentum, conservations theorems, and Hamiltonian equations in different coordinate systems
- Understand and apply variational principles like Euler-Lagrange's and Hamilton's principles in solving dynamic systems
- Solve problems using Hamilton-Jacobi equation particularly in harmonic oscillator and Kepler's problem
- Understand the dynamics of rigid bodies, their generalized coordinates, angular momentum, inertia tensor, and kinetic energy.

Course Outcomes: After successful completion of this course, the learner will able to

- Apply conservation laws to analyze and solve problems related to linear momentum, angular momentum and energy conservation
- Apply Newton's laws of motion to understand and solve problems in central force fields and related motion
- Formulate and solve dynamic problems using Lagrange's and Hamilton's equations for systems with constraints
- Apply variational principles to derive and solve dynamic systems using Euler-Lagrange and Hamilton's principles
- Analyze the dynamics of rigid bodies, understand their properties and solve related problems

Unit 1: Basic Concepts
Newton's law of motion, Motion in a central Force Field, Conservative force

Unit 2: Mechanics of a particle and system of particles
Conservation principle (laws), Mechanics of a particle, Conservation of linear momentum, Conservation of angular momentum, Work, Power and Energy, Conservation of energy, Mechanics of a system of particles

Unit 3: Lagrangian Formulation of Dynamics-I
Constraints, Type of constraints, degree of freedom, Generalized co-ordinates, Principle of virtual work, D'Alembert's Principle, Lagrange's equation for holonomic constraints

Unit 4: Lagrangian Formulation of Dynamics-II
Lagrange's equations for velocity dependent potential, Lagrange's multiplier for holonomic and nonholonomic systems

Unit 5: Hamiltonian Formulation Dynamics
Generalized momentum and Cyclic coordinates, Conservation theorems, Hamiltonian Equations, Hamiltonian equations in different coordinate system, Examples in Hamiltonian Dynamics

Unit 6: Two-Body Central Force Problem
Central Force and Motion in a Plane, Equations of motion under central force and first integral, Differential equation for an orbit, Inverse square law of force, Kepler's laws of planetary motion and their deduction

Unit 7: Variational Principle
Euler's equation of calculus of variation, Euler-Lagrange's principle, Deduction of Hamiltonian's principle from D'Alembert's principle, Modified Hamiltonian's principle, Principle of least action

Unit 8: Canonical Transformation
Canonical transformation, Legendre's transformation, Generating Functions, Condition for canonical transformation

Unit 9: Brackets and Liouville's theorem
Poisson's Brackets, Lagrange's Brackets, Relation between Lagrange and Poisson Brackets, Angular momentum and Poisson Brackets, Liouville's Theorem

Unit 10: Hamiltonian -Jacobi Theory
The Hamiltonian-Jacobi equation, Solution of Harmonic oscillatior problem by Hamilton -Jacobi method, Hamilton-Jacobi equation: Hamiltonian Characteristic Function, Kepler's problem: Solution by Hamiltonian's-Jacobi method

Unit 11: Small Oscillations
Potential energy and Equilibrium-One dimensional oscillator, Two coupled Oscillators, General theory of small oscillations

Unit 12: Dynamics of a Rigid Body-I
Generalized coordinates of a Rigid body, Body and space reference systems, Components of Angular velocity

Unit 13: **Dynamics of a Rigid Body-II**
Angular momentum and Inertia tensor, Principle axes -principle moments of Inertia, Rotational kinetic energy of a rigid body

Unit 14: Noninertial and Rotating coordinate system
Noninertial Frames of references, Fictitious or Pseudo Force, Centrifugal Force, Uniform Rotating Frames, Free fall of a body on Earth's surface

Suggested Readings:

1. Rao, K. Sankara. 2009. *Classical Mechanics*. New Delhi: PHI Learning Private Limited.
2. Upadhyaya, J.C. 2010. *Classical Mechanics*, 2nd Edition. New Delhi: Himalaya Publishing House.
3. Goldstein, Herbert. 2011. *Classical Mechanics*, 3rd Edition. New Delhi: Pearson Education India.
4. Gupta, S.L. 1970. *Classical Mechanics*. New Delhi: Meenakshi Prakashan
5. Takwala, R.G. and P.S. Puranik. 1980. New Delhi: Tata McGraw Hill Publishing.
6.Goldstein, H., Safko, J.and Poole, *Classical Mechanics*,3rd Edition,2001.
7.Rana, N.C. and Joag, P.S. *Classical Mechanics*, Tata McGraw-Hill,2001.

SEMESTER III: Integral Equations and Calculus of Variation

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- make the learner familiarize with resolvent kernel, successive approximation, solution of homogeneous Fredholm integral equation for solving integral equations and variational problems.

Course Learning Outcomes: After successful completion of this course, the learner will able to

- Use the concept of different kernels and techniques for solving various kinds of integral equations.
- Find the solutions of Volterra integral equations using Neumann series method.
- Understand the relation between differential and integral equations.
- Learn about the formulation of variational problems, the variation of a functional and its properties, extremum of functional, sufficient condition for an extremum.

Unit 1: Fredholm Integral Equations

Fredholm integral equation of first kind, Fredholm integral equation of the second kind, Fredholm integral equation of third kind, Homogeneous Fredholm integral equation

Unit 2: Volterra Integral equations

Volterra integral equation of the first kind, Volterra integral equation of the third kind, Volterra integral equation of the second kind, Homogeneous Volterra integral equation

Unit 3: Special types of kernels

Symmetric kernel, Separable kernel, Iterated kernel, Resolvent kernel, Eigenvalues (or characteristic values or characteristic numbers), Eigenfunctions, Leibnitz's rule of differentiation under integral sign

Unit 4: Conversion of ordinary differential equations into integral equations

Initial value problem, Method of converting an initial value problem into a Volterra integral equation, Boundary value problem, Method of converting a boundary value problem into a Fredholm integral equation

Unit 5: Homogeneous Fredholm Integral equations of the second kind with separable (or Degenerate) kernels

Characteristic values (or Characteristic numbers or eigenvalues), Characteristic functions (or eigenfunctions), Solution of homogeneous Fredholm integral equation of the second kind with separable (or degenerate) kernels

Unit 6: Fredholm Integral equations of the second kind with separable (or Degenerate) kernels

Solution of Fredholm integral equations of the second kind with separable (or degenerate) kernels, Fredholm theorem, An approximate method

Unit 7: Method of Successive Approximations
Iterated kernels or functions, Resolvent (or reciprocal) kernels, Solution of Fredholm integral equation of the second kind by successive approximations, Solutions of Volterra integral equation integral equation of the second kind by successive substitutions, Iterative method (Iterative scheme), Neumann series, Solution of Volterra integral equation of the second kind by successive approximations, Solution of Volterra integral equation of the second kind when its kernel is of some particular forms, Solution of Volterra integral equation of the second kind by reducing to differential equation

Unit 8: Integral equations with symmetric kernels
Symmetric kernels, Regularity conditions, the inner product or scalar product of two functions, Solution of the Fredholm integral equation of the first kind with symmetric kernel

Unit 9: Singular Integral equations
Singular integral equation, The solution of the Abel integral equation, General form of the Abel singular integral equation

Unit 10: Variational problems with fixed boundaries
Functionals, Euler’s equation, Another form of Euler’s equation, Particular case of Euler’s equation, Necessary condition of extremum, Sufficient condition for extremums, Functionals dependent on higher-order derivatives, Extension of the variational case: several dependent variables, Isoperimetric problems, Lagrange’s equation

Unit 11: Variational problems with moving boundaries
Transversality Conditions, Variational problems with moving boundary in implicit form, Basic problems with variable end

Unit 12: Sufficient Conditions for an Extremum
General definitions, Jacobi condition, Weirstrass function, Sufficient condition for extremum: Legendre condition, Application of the Calculus of variation, Principle of least action, Lagrange’s equation from Hamilton’s principle

Unit 13: Canonical transformations
Canonical or contact transformation, Conditions for a transformation to be canonical

Unit 14: Direct Methods
Direct methods in variational problems, Ritz Method, Galerkin’s Method, Collocation method

Suggested Readings:
1. Wazwaz, A. M. *A First Course in Integral Equations*. 2nd edition World Scientific Publishing
Co. 2015.
2. Kanwal, R. P. *Linear Integral Equation. Theory and Techniques*. Academic Press, 2014.

3. Gelfand, I. M. and Fomin, S. V. *Calculus of Variations*. Courier Corporation, 2012.
4. Hildebrand, F. B. *Method of Applied Mathematics*, Courier Corporation, 2012.
5. Raisinghania M. D. *Integral Equation & Boundary Value Problem.* S. Chand Publishing, 2007.
6. Jerri, A. *Introduction to Integral Equations with Applications*, John Wiley & Sons, 1999.
7.A.S. Gupta: *Calculus of Variation with applications*, PHI,1999.

SEMESTER IV: Numerical Analysis and Computation

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A:**30,** E.S.E**: 70)**

Course Objectives: The course will enable the learners to

- introduce the basic of systems of linear algebraic equations and their solutions, error analysis, rate of convergence, eigen value problem, solving ordinary differential equations, Finite difference methods for 2D and 3D elliptic boundary value problems.

Course Learning Outcomes: This course will enable the students to:

- Apply Iterative method for matrix inversion.
- Solving of eigen value problem by Jacobi's method, Given's method, Power method.
- Apply Euler's method, Single step Methods, Taylor series method, Runge-Kutta's method to solve ordinary differential equations.
- Apply numerical techniques to obtain approximate solutions to otherwise intractable mathematical problems
- Learn numerical technique to find the solutions of nonlinear equations, system of linear equations, interpolation problems, numerical differentiations and integration, Initial and boundary value problems

Unit -1: Error Analysis and Numerical Computations

Approximate numbers and significant figures, Rounding of numbers, Errors, A general formula for errors, Accuracy in the evaluation of a formula, Computer representation of numbers, Floating point Arithmetic, Propagation of errors, Loss of significant digits, propagation of error in function evaluation

Unit-2: Interpolation

Lagrange and Newton Interpolation, Lagrange Interpolation, Newton divided difference Interpolation, Gregory-Newton backward, Central interpolation, Hermite Interpolation

Unit -3: Spline Interpolation

Quadratic Spline Interpolation, Cubic Spline Interpolation

Unit -4: Solution of transcendental and polynomial equations

Solution of equation, Iterative methods and related concepts, Bisection method, The method of iteration,

Regula-Falsi method, Secant method, Newton-Raphson method, Roots of a polynomial

Unit 5: Interpolation (With equal Intervals)

Newton's forward interpolation, Backward Interpolation formula, Central-difference interpolation

Unit 6: Interpolation (With unequal Intervals)
Lagrange's interpolation formula, Divided difference, Hermite's interpolation formula

Unit 6: The Accuracy of Interpolation Formulas
Error of polynomial approximation, Remainder term in Newton's forward interpolation formula and in Lagrange's formula, Remainder term in Newton's backward formula, Remainder term in Stirling's formula

Unit 7: Numerical Differentiation
Numerical differentiation, Derivatives of the functions at the given arguments unequally spaced

Unit 8: Numerical Integrations
Numerical Quadrature, Quadrature formula for equally spaced arguments, The trapezoidal rule, Simpson's $\frac{1}{3}$ rule, Simpson's $\frac{3}{8}$ rule, Newton-Cote's formula

Unit 10: Numerical Solution of Ordinary Differential Equations
Picard's method, Taylor's series method, Euler's method, Modified Euler's method, Runge-Kutta method, Predictor-Corrector methods, Adams-Bashforth method

Unit 11: Solution of Simultaneous Algebraic Equations
Systems of simultaneous linear equations, Gauss elimination method, LU decomposition method, Jordan's method, Iterative methods: Jacobi method, Gauss-Seidel method, Ill-conditioned system of equations

Unit 12: Numerical Solution of Partial Differential Equation
Finite-difference approximations to partial derivative, Solution to Laplace equation, One dimensional heat equation, One dimensional heat equation, Solution of wave equation

Unit 13: Numerical Algorithm in C-I
Computer codes: Bisection method, Regula-falsi method, Secant method, Newton-Raphson method, Newton forward method, Newton's Backward method

Unit 14: Numerical Algorithm in C-II
Trapezoidal method, Simpson's method, Gauss elimination method, Gauss-Jordan method, Gauss-Seidel method, Jacobi's method

Suggested Readings:

1. Gupta, R. K. *Numerical Methods: Fundamentals and Applications.* 1st edition, Cambridge University Press, 2019.
2. Thangaraj, P. *Computer Oriented Numerical Methods*. PHI Learning Pvt. Ltd, 2013.
3. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. *Numerical Methods for Scientific & Engineering Computation*. New Age International, 2012.
4. Burden R. L. and Faires J. D. *Numerical Analysis*. 9th Edition, Cengage Learning, 2011.
5. Chapra, S. C. and Canale, R. P. *Numerical Methods for Engineers*. McGraw Hill, International Edition, 1998.

6. Mathews, J. H. *Numerical Methods for Mathematics, Science and Engineering*. Prentice-Hall, International Editions, 1992.

SEMESTER IV: Number Theory

Course Type:	**DSC**
Number of Credits:	**4**
Total Marks:	**100** (I.A**:30,** E.S.E**: 70)**

Course Objectives:

The primary objective of this course is to

- Understand the basic concepts of Number theory like congruence and divisibility and their application. They will have the knowledge of famous theorem like Fermat's and Chinese Remainder theorem and their application to other field of science.
- solve the day-to-day problems by using Fibonacci sequence and Pell's equation.
- Course Learning Outcomes: This course will enable the students to:
- Understand the properties of divisibility and prime numbers, compute the greatest common divisor and least common multiples and handle linear Diophantine equations
- Use the operations with congruence's, linear and non-linear congruence equations
- Apply the theorems: Chinese Remainder Theorem, Lagrange theorem, Fermat's theorem, Wilson's theorem

Unit 1: Basic Concepts
Division algorithm, Greatest common divisor, Euclidean algorithm, least common multiple, Kronecker's theorem

Unit 2: Divisibility Theory
Divisibility, Tests of divisibility

Unit 3: Primes and their distribution
Prime numbers, Fundamental theorem of arithmetic

Unit 4: Theory of Congruence-I
Congruence, Basic properties of congruence, Residue system, Linear congruence

Unit 5: Theory of Congruence-II
Solvability condition of a system of linear congruence, The linear Diophantine theorem, The Chinese Remainder Theorem

Unit 6: Fermat's Theorem
Fermat's factorization method, Fermat's little theorem, Wilson's theorem, Euler's factorization method

Unit 7: Number Theoretic Functions-I
The function τ and σ,The mobius function, The greatest integer function, Euler's function, Some properties of Euler's function

Unit 8: Number Theoretic Functions-II
Function $T(n)$,$S(n)$,$\zeta(n)$,$\phi(n)$

Unit 9: Primitive roots and indices
The order of an integer modulo n,Primitive roots, Primitive roots for primes, Composite numbers having primitive roots, The theory of indices

Unit 10: Quadratic Congruence and Quadratic Reciprocity law
Quadratic congruence, Quadratic residue, Euler's residue, Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruences with composite module, Jacobi symbol

Unit 11: Perfect Numbers
Perfect numbers, Mersenne primes, Fermat number, Pythagorean triples, Other Diophantine equation, Fermat's last theorem

Unit 12: Sum of square of Integers
Sum of two square, Sum of more than two squares

Unit 13: Partitions
Introduction, Graphical Representation, Euler's Partition Theorem, Searching for Partition Identities

Unit 14: Farey Sequences and Continued Fractions
Farey Sequence, Continued Fractions, Finite Continued Fractions, Infinite Continued Fractions, Application to Equations, Pell's Equation, Fibonacci Numbers, Fibonacci Sequence, Certain Identities involving Fibonacci Numbers

Suggested Readings:
1.David Burton: Elementary Number Theory, Universal Book Stall, New Delhi

2.George E. Andrews: Number Theory, Hindustan Publishing Corporation, New Delhi

3.K.C. Chowdhury: A First Course in Theory of Numbers, Asian Books Pvt. Ltd.,

4. RamanujacharyKumanduri; Cristina Romero: Number Theory with Computer Applications, Prentice Hall, New Jersey

5.G.H. Hardy; E.M. Wright: An Introduction to the Theory of Numbers, OUP.

6.Thomas Koshy: Elementary Number Theory with Applications, Harcourt Science and Technolgy Company.

7. S.G. Telang (eds. M.G.Nadkarni&J.S.Dani) : Number Theory, Tata McGraw-Hill Publishging Company Limited

8. Gareth A. Jones & J. Mary Jones, Elementary Number Theory, Springer

9. Apostol, T. M. Introduction to Analytic Number Theory. Springer 2014.

10. Niven, I. and Zuckerman, H. S. Introduction to the Theory of Numbers. John Wiley & Sons, 2008.

11. Hardy, G. H. and Wright, E. M. Theory of Numbers. Oxford Science Publications, 2003.

SEMESTER IV: Graph Theory

Course Type: DSC

Number of Credits: 4

Total Marks: 100 (I.A:30, E.S.E: 70)

Course Objectives:

The course will enable the learners to

- introduce the concept of undirected graph, operation and connectedness of graph, different types of graphs, tree, center and centroid, independent cycles and co cycles, Connectivity and traversability, planarity and colorability,

Course Learning Outcomes:

This course will enable the students to:

- Learn and apply the connectedness of graph
- Learn and apply the different types of operations of graph
- Understand tree and its significance and applications in graph theory
- Have the knowledge of point connectivity and line connectivity and their applications
- Applications of Eulerian and Hamiltonian graph
- Learn and apply the Kuratowski's theorem in planar graph
- Learn and apply the point coloring and chromatic number

Unit 1: Introduction to Graph theory

The Konigsberg Bridge problem, Graph: Definition, the degree of a vertex, Isomorphism of graphs, Directed graph or Digraph

Unit 2: Graph Operations

Union of two graphs, Edge and Vertex, Joint of two graphs, Product of two graphs, Homeomorphism of Graphs, Intersection Graphs

Unit 3: Bipartite Graphs

Characterizations of bipartite graphs, Cayley's Formula

Unit 4: Connectivity
Walk, Path, Cycle in a graph, Edge and Vertex connectivity

Unit 5: k-Connected graphs
2-connected graphs, k-Connected and k-edge Connected graphs

Unit 6: Tree
Definition, Properties of Trees, Center and Centroid of Tree, Independent Cycles and Co-cycles, Block cut point tree

Unit 7: Cut-Sets and Cut-Vertices
Cut-sets, some properties of Cut-sets, Cut-vertices, Fundamental circuits and cut-sets

Unit 8: Bridges and Algorithm

Bridges, Breadth-first algorithm, Depth-first algorithm, Prim's and Kruskal algorithm, Dijkstra's algorithm

Unit 9: Traversability

Eulerian Graphs, Hamiltonian Graph, The Shortest path problem, The Chinese Postman problem, The Travelling Salesman Problem

Unit 10: Matching and Coverings

Matchings, Coverings, Dominating Sets and Domination numbers, Factorization, Critical Vertices and Edges

Unit 11: Colorability

Vertex Coloring, Chromatic Polynomial, Edge Coloring

Unit 12: Planarity

Planar graph, Kuratowski's Theorem, Outerplanar Graph, The five Color problem, Dual graphs

***Unit* 13: Matrices: associated with graphs**

Adjancy Matrix, The Incidence Matrix, Cycle Matrix, Path Matrix and Cut-set Matrix

Unit 14: Digraphs

Digraph, Directional Duality and Acyclic Digraph, Matrices associated with Digraphs

Suggested Readings:

1. F. Harary, Graph theory, Narosa Publishing House, New Delhi, 1988.
2. R. Balakrishnan and K. Renganathan, A textbook of Graph theory, Springer, 2000
3. B. Bollobas, Modern Graph Theory, Springer, 2002
4. G. Chartrand, L. Lesniak, Graphs & digraphs (Fourth edition), Chapman & Hall/CRC, 2005.
5. R. J. Wilson, Introduction to Graph Theory (5th Edition), Prentice Hall, 2010

Master of Science (Mathematics)
DETAILED COURSE WISE SYLLABUS

Syllabus of Discipline Specific Elective (DSE) Courses

SEMESTER I: Computer Programmeming using C

Course Type: DSE

Number of Credits: 4

Total Marks: 100 (I.A:30, E.S.E: 70)

Course Objectives:

The course will enable the learners to

- Develop proficiency in programmeming using the C language.
- Understand basic programmeming concepts such as data types, variables, control structures, functions, and arrays.
- Acquire skills to design and implement efficient algorithms and programmes using C language.
- Learn to use C programmeming to solve real-world problems and challenges.
- Course Outcomes: Course Outcomes: After successful completion of this course, the learner will able
- write and debug C programmes using programmeming constructs like variables, data types, control structures, functions, arrays, and pointers.
- design and implement programmes that meet specific requirements using C programmeming techniques, algorithms, and data structures.
- apply their skills to a wide range of real-world problems. This includes the ability to analyze a problem, break it down into smaller parts, and develop a solution using

programmemingconcepts.

Unit 1: Introductory Concepts
Basic definition of Pseudo Code, algorithm, flowchart, programme

Unit 2: Elements of C Programmeming
Characters used in C, Identifiers, Keywords, Tokens, Constants, Variables, Types of Cvariables, Receiving input and output

Unit 3: Variables and Data types
Integer, character floating point and string; Initialization of variable during declarations;Symbolic Constants, type conversion in assignment

Unit 4: Operators and Expressions
Expression in C, Different types of operators: Arithmetic, Relational and Logical, Assignment,Conditional, Increment and decrement, Bitwise, Comma and other operator (size of, periodetc). Precedence and associatively of operators, type casting

Unit 5: I/O Functions
Header Files (stdio, conio), Formatted Input/Output Functions (scanf, printf), EscapeSequences, Character Input/Output Functions (getch, getchar, putchar, gets, puts, getche,clrscr)

Unit 6: Preprocessor Directives Features of C preprocessor, Macro expansion, Macros with arguments, #if and #elifDirectives

Unit 7: Conditional Statements
Conditional Statement- if, if- else, nested if-else, switch-case; break, continue, goto

Unit 8: Loop Control Structures
Concept of Loops, Types of loops: while, do-while, for; nested loops

Unit 9: Storage Class
Automatic, External, Static, Register, Scope and lifetime of variables, Macro, PreprocessorDirective

Unit 10: Arrays
Array, Array Declaration, 1-Dimensional array, 2-Dimensional array

Unit 11: Strings
String, String Handling Functions: strlen(), strcmp(), strcpy(), strrev(), strcat(), etc

Unit 12: Functions
Function, Function declaration, Function definition, Function call, Formal and Actualparameter, Recursive function

Unit 13: Pointers
Pointer, Pointer declaration, Passing pointer to a function, Pointer and one-dimensional arrays,Dynamic memory allocation

Unit 14: Structures and Union
Structure Declarations, Definitions, Defining your typedef, Array of Structure, Pointer toStructure. Union Declaration, Definition, Declaration, Uses

Unit 15: File Handling
Concept of File, File Pointer, File Opening in various modes, closing a file, reading and writingon files, Formatted Input/Output, fseek(), ftell(), rewind()

Suggested Readings:
1. Kanetkar, Y. (2018). Let Us C (16th ed.). Delhi: BPB Publications.

2. Balaguruswamy, E. (2019). Programmeming in ANSI C (7th ed.). Delhi: Tata McGraw-Hill

Education Private Limited

SEMESTER II: Operations Research

Course Type: DSE

Number of Credits: 4

Total Marks: 100 (I.A:30, E.S.E: 70)

Course Objectives:

The course will enable the learners to

- Formulate and model a linear programmeming problem from a word problem and solve them graphically in 2 and 3 dimensions.
- Formulate and solve a number of problems in game theory using various methods.

Course Outcomes:

After successful completion of this course, the learner will able

- Understand the concept of operations research methods and its uses in various fields.
- Learn about the graphical solution of linear programmeming problem with two variables.
- Learn about the relation between basic feasible solutions and extreme points.
- Understand the theory of the simplex method used to solve linear programmeming problems.
- Learn about the relationships between the primal and dual problems
- Solve transportation and assignment problems

UNIT 1: Introduction to operations research

Historical Background, Scope of Operations Research, Features of OperationsResearch, Phases of Operations Research, Types of Operations Research Model, Operations Research Techniques and Tools, General Methods for Solving Operations Research Model, Limitations of Operations Research

UNIT 2: Linear programmeming problem (LPP)
Linear programmeming problem (LPP), General form of Linear programmeming problem (LPP), Some important definitions, Basic assumption of LPP, Application of LPP, Limitations of LPP, Mathematical formulation of LPP

UNIT 3: Graphical method of solution for LPP
Some basic definition, Graphical methods to solve LPP, Some special cases,Limitations of graphical method

UNIT 4: Simplex Method
Standard Form of Linear Programmeming Problem (LPP), General LPP, Canonical and Standard Forms of LPP, Solution of LPP, Fundamental Theorem of LPP, the Simplex Algorithm, Big-M Method, Two-Phase Method

UNIT 5: Duality in Linear programmeming problem
Importance of Duality Concepts, Formulation of Dual Problem, Economic Interpretation of Duality, Sensitivity Analysis

UNIT 6: Transportation Problem
Formulation of Transportation Problem (TP), Basic Theorems on TP, Initial Basic Feasible Solution: North-West Corner Method, Matrix-Minima Method, Vogel Approximation Method, Optimality Test, Algorithm of MODI Method

UNIT 7: Assignment problem
Formulation of an Assignment Problem, Assignment Problem as a Special Case of Transportation Problem, Solution of an Assignment Problem, The Hungarian Method of Solution of an Assignment Problem, The Travelling Salesman Problem (Shortest Cyclic Route Model)

UNIT 8: Game theory
Competitive Situations, Characteristics of Competitive Games, Two-Person Game, Two-Person Zero-Sum Game, Pay-off Matrix, Strategy,

Maximin and Minimax Principle, Saddle Point, Value of a Game, and Symmetric Game, Dominance Property

Unit 9: Introduction to project Management
Meaning and Features of Project, Meaning of Project Management, Need of Project Management, Life Cycle of a Project, Life Cycle Curve

Unit 10: Project Planning
Project Planning, Planning of Physical, Human and Financial Resources

Unit 11: Project Scheduling and PERT, CPM
Project, Project planning, Project Scheduling Network and its basic components, Procedure relationship, CPM, PERT, Basic difference between PERT and CPM

UNIT 12: Project completion and Evaluation
Integrated Power Management Control System, Project Management, Transition, Project Completion and Evaluation, Project Review and Termination

Unit 13: Sequencing
Definition and examples, Johnson's algorithm, Three machine problem, Processing of two jobs on 'n' machines

Unit 14: Non-linear Programmeming
Formulation of a non-linear programmeming problem (NLPP), General non-linear programmeming problem, Constrained optimization with equality constraints, Constrained optimization with inequality constaints, Saddle point problems, Saddle points and NLPP

Suggested Readings:

1. Operations Research: Prem Kuman Gupta, D. S. Hira :S. Chand &Company Ltd.
2. Operations Research: Kanti Swarup, P. K. Gupta, Man Mohan (Sultan Chand and Sons)

3. Panneerselvam: Operations Research (2006), Prentice Hall of India Private Limited, New Delhi.
4. Sharma, S. D. Operation Research, Kedar Nath Ram Nath Publications, 2012.
5. Swarup, K. and Gupta, P.K. Operations Research. S. Chand publisher, 2010.
6. Taha, H. A. Operation Research: An Introduction.9th edition, Pearson, 2010.
7. Gupta, P.K. and Hira, D.S. Introduction to Operations Research, S. Chand & Co. 2008.
8. Sharma, J. K., Mathematical Model in Operation Research, Tata McGraw Hill, 1989.

SEMESTER III: Measure theory and Integration

Course Type: DSE

Number of Credits: 4

Total Marks: 100 (I.A:30, E.S.E: 70)

Course Objectives:

The course will enable the learners to

- Understand and apply the Lebesgue measure in determining lengths of intervals, open and closed sets, and the concept of Lebesgue measurable sets including Borel sets
- Understand the definitions and properties of outer measure, measurable sets, and regularity of measures
- Compute Lebesgue integrals for bounded and unbounded functions over intervals and subsets of real numbers and understand theorems related to general Lebesgue integrals

Course Outcomes:

After successful completion of this course, the learner will able

- Calculate Lebesgue measures for intervals, open and closed sets, and determine Lebesgue measurable sets and Borel sets
- Calculate outer measures and identify measurable sets
- Compute Lebesgue integrals for bounded and unbounded functions, apply theorems related to general Lebesgue integrals
- Apply the concepts of signed measures, decomposition theorems, absolute continuity and the Radon-Nikodym theorem

Unit 1: Countability of Sets and Cardinal Numbers

Countable set, Algebraic numbers, Cardinal number of a set, Transcendental numbers

Unit 2: Open sets and Closed sets on the real line
Intervals, Open sets, closed sets

Unit 3: Lebesgue Measure in the real line
Length of intervals, Lengths of open and closed sets, Lebesgue inner measure, Lebesgue measurable set, Borel sets and their measurability

Unit 4: Outer Measure and Measurability
Definitions, Ideal measure function, Measurable set, Regularity of measure

Unit 5: Measurable Functions
Definitions, Borel measurable functions

Unit 6: The Lebesgue Integral of a Function-I
Lebesgue integral of bounded function on Interval [a,b],Lebesgue integral for bounded functions over a subset of real numbers

Unit 7: The Lebesgue Integral of a Function-II
General Lebesgue integral for unbounded functions, Integral of non-negative function, Theorem on general Lebesgue Integrals

Unit 8: Convergence of Sequence of Measurable Functions
Convergence almost everywhere, Pointwise convergence, Convergence in measure, Uniform convergence almost everywhere, Little wood's three principle

Unit 9: Differentiation and Integration
Absolute Continuous functions, Monotone functions, Functions of bounded variation, Vitali's lemma, Indefinite integral, Four Dini's derivatives

Unit 10: L^p Spaces
L^p space, Norm of an element of L^p-Space,Riesz-Holder inequality, Schwarz or Cauchy -Schwarz inequality, Minkowski's or Riesz-Minkowski's inequality, Properties of L^p Spaces, L^p Spaces for $p=\infty$

Unit 11: Signed Measure

Definition: Signed measure, Positive, Negative and Null sets, Hahn decomposition theorem, Jordan decomposition, singular measure, Absolutely continuous measure function, Radon-Nikodym theorem

Unit 12: Product Measure

Product of two sets, Rectangle, Sections, Product measure, Double integral, Iterated integrals, Fubini's theorem

Unit 13: Measurable functions and their Integrals

Measurability relative to a basic ring, Topology of sequential convergence, Fundamental existence theorem

Unit 14: Extension of the Lebesgue Integral

Uniqueness theorem, General Denjoy Integral

Suggested Readings:

1. Lawrence C. Evans and Ronald F. Gariepy, Measure Theory and Fine Properties of Functions. CRC Press, Taylor & Francis Group,2015
2. Donald L. Cohn: Measure Theory, Springer,2013.
3. Terence Tao: An Introduction to Measure Theory, American Mathematical Society (AMS),2011
4. Sheldon Axler: Measure, Integration & Real Analysis, Springer's Graduate Texts in Mathematics series,2020.
5. Robert G. Bartle: A modern theory of integration, Graduate Studies in Mathematics. MS, vol 32 2001.

SEMESTER III: Fluid Dynamics

Course Type: DSE

Number of Credits: 4

Total Marks: 100 (I.A:30, E.S.E: 70)

Course Objectives:

The course will enable the learners to

- Prepare a foundation to understand the motion of fluid and develop concept, models and techniques which enables to solve the problems of fluid flow and help in advanced studies and research in the broad area of fluid motion.
- provide a treatment of topics in fluid dynamics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems.
- provide the student with knowledge of the fundamentals of fluid dynamics and an appreciation of their application to real world problems.

Course Outcomes:

After successful completion of this course, the learner will able

- Use the concept of stress in fluids with applications.
- Analyse Irrotational and rotational flows in fluids and some of their properties
- formulate mass and momentum conservation principle and obtain solution for nonviscous flow.
- understand the concept of stress and strain in viscous flow and to derive Navier□Stokes equation of motion and solve some exactly solvable problems.
- derive the path-lines and the streamlines in Cartesian and polar form from a velocity field
- derive the stream function from a velocity field
- understand how the equations of continuity is derived

(conservation of mass) and its consequences about compressibility.

- understand how Euler's equation is derived, what it represents, and use it to find the pressure distribution from a velocity.and deduce Bernoulli's equation.
- understand how Navier-Stoke's Equation (Consideration of viscosity) is derived some exact solutions of Navier-Stoke's Equation model different flows from a combination of uniform flows, sources, sinks and doublets

Unit-1: Introduction

Some basic properties of fluid, Viscous and inviscid fluids, Viscosity, Newtonian and non-Newtonian fluids, Real and ideal fluids, Some important types of flows

Unit-2: Kinematics of fluids in motion

Methods of describing fluid motion, Lagrangian method, Eulerian method, Velocity of a fluid particle, Acceleration of a fluid particle, Stream line, Path line, Streak line, Velocity potential

Unit-3: Equation of Continuity

The equation of continuity (or equation of conservation of mass) by Euler's method, the equation of continuity in cartesian coordinates, the equation of continuity in cylindrical coordinates, the equation of continuity in spherical polar coordinates, Equation of continuity in generalized orthogonal curvilinear coordinates, The equation of continuity by the Lagrangian method.

Unit-4: Equation of Motion of inviscid flows

Euler's equation of motion, The equation of motion of an inviscid fluid, Conservative field of force, Euler's equation of motion in cylindrical coordinates, Euler's equation of motion in Spherical coordinates, The energy equation

Unit-5: One-dimensional inviscid incompressible flow
Integration of Euler's equation of motion, Bernoulli's equation, Pressure equation, Bernoulli's theorem

Unit-6: Motion in two dimensions (Sources & Sinks)
Motion in two-dimension, Stream function or current function, Physical significance of stream function, Irrotational motion in two-dimensions, Complex potential, Sources and Sinks, Sources and Sinks in two dimensions

Unit-7: General theory of irrotational motion
Connectivity, Flow and circulation, Stokes's theorem, Kelvin's circulation theorem, Green's theorem, Kelvin's minimum energy problem

Unit-8: Motion of Cylinders
Boundary conditions for stream function, General motion of cylinder, Kinetic energy of liquid

Unit-9: Motion of a Sphere (Motion in three dimension)
Equation of continuity, Liquid streaming past a fixed sphere, Equation of a sphere

Unit-10: Stokes's Stream function
Stoke's function, Property of Stoke's function, Irrotational motion, Solution for ψ,Motion of a solid of revolution along the axis, Motion of liquid inside a rotating ellipsoid sphere, Motion of an ellipsoid in an infinite mass of a liquid

Unit-11: Vortex Motion
Vorticity, Vorticity components, Vortex line, Vortex tube and vortex filaments, Helmholtz's vorticity theorems, Properties of vortex tube, Two vortex filaments, Motion of any vortex, Kirchhoff vortex theorem

Unit-12: Waves
General expression of a wave motion, Mathematical expression of wave motion, Standing or stationary motion, Types of liquid waves, Surface

waves, The energy of progressive waves, The energy of stationary waves, Capillary waves or Ripples

Unit-13: Viscosity

Most general motion of a fluid element, Strain tensor, Strain Analysis, Stress Analysis, Newtonian and non-newtonian fluids. Principal stresses and Stoke's relation

Unit-14: The Navier-Stokes Equations and the energy equation

The Navier-Stokes equation of motion of a viscous fluid, some exact solutions of Navier-Stokes equation

Unit-15: Boundary Layer Flow

Prandtl's boundary layer theory, Boundary layer equations, Prandtl's number, Euler's number, Froude number, Weber number, Mach number, Eckert number

Suggested Readings:

1. Besaint, W.H. and Ramsey, A.S. A Treatise on Hydromechanics Part Ihydrostatics, Andesite Press, 2017.
2. Kundu, P.K., Cohen, I. M. and Dowling, R. D. Fluid Mechanics, 6th edition, Academic Press, 2015.
3. O'Neil, M. E., and Chorlton, F. Ideal and Incompressible Fluid Dynamics. Ellis Horwood Ltd, 1986.
4. Yuan, S.W. Foundations of Fluid Mechanics. Prentice Hall of India Private Limited, New Delhi, 1976.
5. Curle, N. and Davies, H. J. Modern Fluid Dynamics.Vol1, D Van Nostrand Company Ltd, London, 1968.
6. Raisinghania, M. D. Fluid Dynamics. S. Chand & Company Ltd., New Delhi, 2001

SEMESTER IV: Differential Geometry

Course Type: DSE

Number of Credits: 4

Total Marks: 100 (I.A:30, E.S.E: 70)

Course Objectives:
The course will enable the learners to

- understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developable and geodesics.

Course Outcomes:
After successful completion of this course, the learner will able to

- Learn about the concepts of curvature, torsion, involutes and evolutes.
- Familiarize with several concepts of tangent plane, Helicoids, metric and direction coefficients.
- Understand the concepts of developable surfaces.
- Use the several notions of curvatures such as geodesic curvature and Gaussian curvatures.

Unit 1: Tensor Algebra
Contravariant and Covariant vector, Definition of tensor, Gradient, Tensor field, Addition and subtraction of tensors, Multiplication of tensors, Inner product, Contraction, Symmetric tensor, Antisymmetric tensor, Quadratic law, Reciprocal tensor

Unit 2: Riemannian metric
Metric,g_ii is a second rank covariant symmetric tensor, Length of a curve, Magnitude of a vector, Unit tangent vector, Associate vectors, Scalar product, Projection of a vector along a direction, Gradient of a scalar function, Angle between two vectors, Angle between co-ordinate curves, Hypersurface, Angle between coordinate hypersurface

Unit 3: Christoffel symbols covariant differentiation

Christoffel symbols, Tensor laws of transformation of Christoffel symbols, Covariant derivative of a covariant vector, Covariant derivative of a covariant second rank tensor, Covariant derivative of a scalar, Divergence of vector, Covariant constant, Curl

Unit 4: Curves in Space-I

Space curve, Class or Function of a Curve, Tangent, Tangent line at a point on a space curve, Order of contact between curves and surfaces, Arc length, Osculating plane, Normal lines and Normal Plane, Rectifying Plane, Fundamental Planes, Equation of the principal normal and Binormal, Curvature, Torsion, Screw Curvature, Serret Frenet formulae, Curvature and Torsion of any curve r=r(t)

Unit 5: Curves in Space-II

Direction cosines of the principal normal and Binormal, Curvature and Torsion of a Curve given by the intersection of two surfaces, Cylindrical Helices, Circular Helix, Intrinsic Equations, Fundamental Theorems for Space curves, Osculating Circle (or the circle of curvature), the osculating sphere (or the sphere of curvature)

Unit 6: Involute and Evolute

Involute of a given space curve, Evolute of a give curve, Curvature and Torsion of the Evolute

Unit 7: Concept of A Surface and Envelopes and developable

Class of a surface, Regular (or Ordinary) point and singularities on a surface, Transformation of parameter, Geometrical transformation of proper transformation, Curvilinear Equations of the curve on the surface, Parametric curve, Tangent plane and Normal, Family of surfaces

Unit 8: Fundamental Forms and Curvature of surfaces

First fundamental Form or Metric, Geometrical Interpretation of metric, An important relation between the coefficients E,F,G and

H,Importantproperties of the matric, Element of area, Angle between the parametric curves, Second fundamental form and second order magnitudes, Surface of revolution, Family of curves

Unit 9: Local non-intrinsic properties of a Surface

Normal curvature, Principal Directions, Minimal surface, Developable surface, Lines of curvature

Unit 10: Conjugate and Asymptotic Lines

Conjugate directions, Condition of conjugate, Principal property of conjugate directions

Unit 11: Asymptotic Lines

Asymptotic lines, Condition for asymptotic lines to be orthogonal, Asymptotic lines on a ruled surface, Formulae of curvature and torsion of an asymptotic line

Unit 12: Fundamental Equations of Surface theory and parallel surfaces

The Fundamental equation of surface theory, Parallel surfaces, Gaussian curvature and Mean curvature for the parallel surface

Unit 13: Geodesics

Geodesics, Canonical geodesic equations, Nature of geodesics on a surface of revolution, Normal property of geodesics, Differential equations of geodesics by using normal property, Torsion of geodesic, Geodesic tangent

Unit 14: Geodesics Curvature

Geodesic curvature, Formula for geodesic curvature, Geodesic parallels, Geodesics co-ordinate, Geodesic polar co-ordinates, Angle between a curve on a surface and a Geodesic through a pole, Geodesic mapping

Suggested Readings:

1. Weatherburn, C. E. Differential Geometry of Three Dimensions, Cambridge University Press, 2016.

2. Graustein, W. C. Differential Geometry. Courier Corporation, 2012.
3. Wilmore T. J. An Introduction to Differential Geometry, Dover Publications Inc., 2012.
4. Pressley, A. Elementary Differential Geometry. Springer, 2002.

SEMESTER IV: Fuzzy Sets and Applications

Course Type: DSE

Number of Credits: 4

Total Marks: 100 (I.A:30, E.S.E: 70)

Course Objectives:
The course will enable the learners to

- introduce the fundamental concepts in fuzzy sets, fuzzy relations, arithmetic operations on fuzzy sets, probability theory, fuzzy logic and its applications

Course Outcomes:
After successful completion of this course, the learner will able to

- Understand the basic concepts of t- norms, t- conforms and operation of
- Use the concepts of approximation of triangular fuzzy number, operations of trapezoidal fuzzy number, bell shape fuzzy number, crisp function and its applications.
- Analyse the Integration and differentiation of fuzzy function product set, and understand the basic concepts of composition of fuzzy relation, fuzzy graph, projection

Unit 1: Fuzzy Set
Concepts of fuzzy set, Types of Fuzzy sets, Characteristic of Fuzzy sets, General properties

Unit 2: Operations on Fuzzy Sets
Extension principle for Fuzzy sets, Fuzzy Compliments, fuzzy union, fuzzy intersection, other operations in fuzzy set, t-Norms and t-Conorms

Unit 3: Fuzzy Numbers and Arithmetic
Fuzzy numbers, Algebraic operations with Fuzzy numbers, Binary operations of two Fuzzy numbers, Fuzzy arithmetic, Arithmetic

operations on Fuzzy numbers in the form

Unit 4: Fuzzy Relations

Projections and cylindrical Fuzzy relations, Composition, Properties of Min-Max composition, Binary relations on a single set, Compatibility relation, Fuzzy ordering relation

Unit 5: Fuzzy Graph

Fuzzy graph, Fuzzy Morphisms

Unit 6: Possibility Theory

Fuzzy measures, Evidence theory, Probability measure, Possibility and necessity measure, Possibility distribution as Fuzzy sets

Unit 7: Approximate reasoning

Fuzzy Implications, Axioms of Fuzzy Implications, Selection of Fuzzy Implications

Unit 8: Fuzzy Logic

Fuzzy logic and Fuzzy proposition, Fuzzy connectives, Fuzzy Inference, Fuzzy Propositions, Fuzzy Quantifiers, Linguistic Hedges, Inference from Conditional Fuzzy Propositions

Unit 9: Fuzzy Systems and Fuzzy Control

Fuzzy rule-based system, Fuzzification and Defuzzification, Fuzzy Control, Assumption in a Fuzzy control system Design, Design of Fuzzy Controllers, Fuzzy Control systems Models, Examples of Fuzzy systems

Unit 10: Uncertainty Based Informations

Uncertainty based Information, Simple, Joint and Conditional uncertainties, On-interactive sets, Information transmission, On-specificity of Fuzzy sets, Degree of validity of Credibility, Fuzziness, Total uncertainty, Fuzziness in evidence theory

Unit 11: Decision making in Fuzzy Environment

Individual Decision making, Multiperson Decision making, Multicriteria

Decision making, Fuzzy Rankin method

Unit 12: Fuzzy Linear Programmeming
Fuzzy linear programmeming, Special cases of Fuzzy linear programmeming

Unit 13: Fuzzy Topological Space
Concept of a Fuzzy points and its Neighbourhood Structure, Fuzzy points and Level sets, Local base

Unit 14: Fuzzy Product Induced Space
Fuzzy product spaces, Fuzzy Continuity, Product-Induced Spaces

Unit 15: Fuzzy Metric Space
Fuzzy Metric Spaces, Fuzzy Metrization, Fuzzy Continuous Functions

Suggested Readings:

1. Mohan, C. An Introduction to Fuzzy Set Theory and Fuzzy Logic. Anshan Publishers, 2015.
2. Lee, K. H. First Course on Fuzzy Theory and Applications. Springer International Edition, 2005.
3. Yen, J., Langari, R. Fuzzy Logic - Intelligence, Control and Information Pearson Education, 1999.
4. Zimmerman, H.J. Fuzzy Set Theory and its Applications. Allied Publishers Ltd., New Delhi, 1991.