Estd. 1962 "A++" Accredited by NAAC(2021) With CGPA 3.52	**SHIVAJI UNIVERSITY, KOLHAPUR - 416 004, MAHARASHTRA** www.unishivaji.ac.in, bos@unishivaji.ac.in **शिवाजी विद्यापीठ, कोल्हापूर - ४१६ ००४,महाराष्ट्र** दूरध्वनी - ईपीएबीएक्स - २६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९३/९४	

SU/BOS/Science/480 **Date: 01/07/2023**

To,

The Principal, All Concerned Affiliated Colleges/Institutions Shivaji University, Kolhapur	The Head/Co-ordinator/Director All Concerned Department (Science) Shivaji University, Kolhapur.

Subject: Regarding syllabi of M.Sc. Part-II (Sem. III & IV) as per NEP-2020 degree programme under the Faculty of Science and Technology.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, nature of question paper and equivalence of M.Sc. Part-II (Sem. III & IV) as per NEP-2020 degree programme under the Faculty of Science and Technology.

M.Sc. Part-II (Sem. III & IV) as per NEP-2020			
1.	Mathematics	8.	Botany
2.	Mathematics (Distance Mode)	9.	Electronics
3.	Mathematics (Online Mode)	10.	Zoology
4.	M.Sc. Tech (Industrial Mathematics With Computer Application)	11.	Agro Chemical and Pest Management (AGPM)
5.	Geography	12.	Alcohol Technology
6.	Statistics	13.	Sugar Technology
7.	Applied Statistics and Informatics	14.	Geology

This syllabus, nature of question and equivalence shall be implemented from the academic year 2023-2024 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website **www.unishivaji.ac.in**)

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2023 & March/April 2024. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Dy Registrar
Dr. S. M. Kubal

Copy to:

1	The Dean, Faculty of Science & Technology	8	P.G. Admission/Seminar Section
2	Director, Board of Examinations and Evaluation	9	Computer Centre/ Eligibility Section
3	The Chairman, Respective Board of Studies	10	Affiliation Section (U.G.) (P.G.)
4	B.Sc. Exam/ Appointment Section	11	Centre for Distance Education

SHIVAJI UNIVERSITY, KOLHAPUR

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Accredited by NAAC: A++ Grade with CGPA 3.52

Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)

Syllabus for Online Mode

M.A./M. Sc. Mathematics Part-II

Semester III and IV

(Syllabus to be implemented from the AcademicYear2023-24)

M.A./M. Sc.(Mathematics)(Part-II/Level-9) (Semester III)

Course code	Title of course
CC-301	Functional Analysis
DSE-302	1. Advanced Discrete Mathematics
CCS-303, CCS-304, CCS-305, CCS-306	1. Non - Linear Optimization Techniques 2. Fuzzy Mathematics –I 3. Fluid Dynamics 4. Combinatorics
AEC-307	Communicative English-II
EC(SWM MOOC)-308	

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code:CC-301
Title of Course: Functional Analysis
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:
1. understand the fundamental topics, principles and methods of functional analysis.
2. demonstrate the knowledge of normed spaces, Banach spaces, Hilbert space.
3. define continuous linear transformations between linear spaces, bounded linear functionals.
4. apply finite dimensional spectral theorem.
5. identify normal, self adjoint, unitary, normal operators.

Unit I: Normed linear spaces, Banach spaces, quotient spaces, continuous linear transformations, equivalent norms, finite dimensional normed spaces and properties, conjugate space and separability, The Hahn-Banach theorem and its consequences. **15 Lectures**

Unit II: Second conjugate space, the natural embedding of the normed linear space in its second conjugate space, reflexivity of normed spaces, the open mapping theorem, projection on Banach space, the closed graph theorem, the conjugate of an operator, the uniform boundedness principle. **15 Lectures**

Unit III: Hilbert spaces: examples and elementary properties, orthogonal complements, the projection theorem, orthogonal sets, the Bessel’s inequality, Fourier expansion and Perseval's equation, separable Hilbert spaces, the conjugate of Hilbert space, Riesz's theorem, the adjoint of an operator. **15 Lectures**

Unit IV: Self adjoint operators, normal and unitary operators, projections, eigen values and eigenvectors of an operator on a Hilbert space, the determinants and spectrum of an operator, the spectral theorem on a finite dimensional Hilbert space. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Book(s):

1. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw Hill, 1963.

Reference Books:

1. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 1978.
2. A. E. Taylor, Introduction to Functional analysis, John Wiley and sons,1958.
3. J. B. Convey, A course in Functional Analysis, Springer-Verlag, 1985.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1972.
5. B. V. Limaye, Functioned Analysis, New age international, 1996.

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code :DSE-302
Title of Course: Advanced Discrete Mathematics
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:
1. classify the graphs and apply to real world problems.
2. simplify the graphs using matrix.
3. study Binomial theorem and use to solve various combinatorial problems.
4. simplify the Boolean identities and apply to switching circuits.
5. locate and use information on discrete mathematics and its applications.

Unit I: Graph: Definition, examples, isomorphism, simple graph, bipartite graph, complete bipartite graph, vertex degrees, regular graph, sub-graphs, complement of a graph, self complementary graph, paths and cycles in a graph, the matrix representation of a graph.

15 Lectures

Unit II: Fusion, definition and simple properties of a tree, bridges, spanning trees, cut vertices, Euler tours and Hamiltonian cycles, Fleury's Algorithm, Hamiltonian graphs, plane and planar graphs.

15 Lectures

Unit III: Principle of inclusion and exclusion, Pigeonhole principle, permutations and combinations, Binomial theorem, discrete numeric functions, manipulation of numeric functions, generating functions, linear recurrence relations with constant coefficients, particular solutions of linear recurrence relations, total solutions, solution by the method of generating function.

15 Lectures

Unit IV: Posets: definition, examples, Hasse diagrams of posets, supremum and infimum, isomorphic ordered sets, duality. Lattices: Definition, examples, sublattices. Ideals: definition, examples, bounded lattices, distributive lattices, modular lattices, complemented lattices, Boolean algebra, basic definitions, basic theorems, Boolean algebras as lattices, CNF, DNF, applications of Boolean algebra to switching circuit.

15 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended books:

1. John Clark and Derek Holton, A first look at Graph Theory, Allied Publishers Ltd., 1991.
2. C.L. Liu, D. P. Mohapatra, Elements of Discrete Mathematics, Tata McGraw Hill Pvt Ltd, 1985.
3. G. Gratzer, General Lattice Theory, Birkhauser, 2002.
4. J. Eldon Whitesitt, Boolean Algebra and Its Applications, Addison-Wesley PublishingCompany, Inc.,1961.

Reference books:

1. Seymon Lipschutz and Mark Lipson, Discrete Mathematics (second edition) Tata Mc Graw Hill Publishing Company Ltd. New Delhi.
2. Richard A. Brualdi, Introductory Combinatorics, Pearson, 2004.
3. Garrett Birkhoff: Lattice Theory, American mathematical society, 1940.

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code: CCS-303, CCS-304, CCS-305, CCS-306
Title of Course: Non - Linear Optimization Techniques
Total Credits: 04

Course Outcomes-: Upon successful completion of this course, the student will be able to:-

1. construct linear integer programming models and discuss the solution techniques.
2. formulate the nonlinear programming models.
3. propose the best strategy using decision making methods.
4. solve multi-level decision problems using dynamic programming method.

Unit I : Non – Linear Optimization Techniques : Introduction. Unconstrained Problems of Maxima and Minima. Constrained Problems of Maxima and Minima. Constraints in the form of Equations :Lagrangian method. Generalized to n – dimensional case. Sufficient condition for maximum (minimum) of objective function with single equality constraint. Sufficient condition for maximum (minimum) of objective function with more than one equality constraints, bondered Hessian matrix, sign definite matrix.

15 Lectures

Unit II : Sufficient condition for maximum and minimum. Constraints in the form of inequalities: Kuhn Tucker necessary and sufficient condition. **Non – Linear Programming Problem :** Practical solutions of of Non – inequalities. Formulation. General Non – Linear Programming Problem. Canonical form of Non – Linear Programming Problem. Graphical Solution.

15 Lectures

Unit III : Quadratic Programming : Introduction. Kuhn Tucker Conditions: Non – Negative Constraints. Wolfe's Modified Simplex Method. Important remarks on Wolfe's Method. Beale's Method. Simplex method for Quadratic Programming. **15 Lectures**

Unit IV : Dynamic programming: Introduction. Decision Tree and Bellman's Principle of Optimality. Solution of problem with a finite number of stages. Single additive constraints, multiplicative separable return, single multiplicative constraints, additively separable return, system involving more than one constraint. Application of dynamic programming in Linear programming.

15 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Books :

1. S.D. Sharma: Operations Research , Kedar Nath Ram Nath and Co.
2.J. K. Sharma: Operations Research Theory and Applications, Mac Millan Co**.**

Reference Books :

1. Kanti Swarup, P. K. Gupta and Manmohan : Operations Research , S. Chand & Co.
2. Hamady Taha : Operations Research : Mac Millan Co.
3. S. D. Sharma : Nonlinear and Dynamic Programming, KedarNath Ram Nath and Co. Meerut.
4. R. K. Gupta : Operations Research, Krishna Prakashan Mandir , Meerut.

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code: CCS-303, CCS-304, CCS-305, CCS-306
Title of course: Fuzzy Mathematics-I
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. acquire the knowledge of notion of crisp sets and fuzzy sets,
2. understand the basic concepts of crisp set and fuzzy set,
3. develop the skill of operation on fuzzy sets and fuzzy arithmetic,
4. demonstrate the techniques of fuzzy sets and fuzzy numbers.
5. Apply the notion of fuzzy set, fuzzy number in various problems.

Unit I: Fuzzy sets and crisp sets, examples of fuzzy sets, types of fuzzy sets, standard operations, cardinality, degree of subset hood, level cuts and its properties, **r**epresentation of fuzzy sets, decomposition theorems,extensionprinciple,propertiesofdirectandinverseimagesoffuzzysets.

20 Lectures

Unit II: Operations on fuzzy sets, types of operations, fuzzy complement, equilibrium and dual point, Increasing and decreasing generators, fuzzy intersection: t-norms. **15 Lectures**

Unit III: Fuzzy union t-conorms, characterization theorem of t-conorm, combination of operators, aggregation operations, ordered weighted averaging operations. **15 Lectures**

Unit IV: Fuzzy numbers, characterization theorem, linguistic variables, arithmetic operations on intervals, arithmetic operations on fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.

10 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Books:

1. GeorgeJ.Klir,BoYuan,FuzzysetsandFuzzyLogic.TheoryandApplications,PHI,Ltd.2000

Reference Books:-

1. M. Grabish, Sugeno,and Murofushi Fuzzy Measures and Integrals: Theory and Applications, PHI, 1999.
2. H. J. Zimmerermann, Fuzzy Set Theory and its Applications, Kluwer,1984.
3. M. Hanss, Applied Fuzzy Arithmetic, An Introduction with engineering Applications, Springer-Verlag Berlin Heidelberg 2005.
4. M. Ganesh, Introduction to Fuzzy Sets & Fuzzy Logic; PHIL earning Private Limited, New Delhi 2011.
5. Bojadev and M. Bojadev, Fuzzy Logic and Application,World Scientific Publication Pvt. Ltd. 2007.

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code: CCS-303, CCS-304, CCS-305, CCS-306
Title of Course: Fluid Dynamics
Total Credits : 04

Course Outcomes: Upon successful completion of this course, the student will be able to:
1) explain physical properties of fluids.
2) represent general motion of fluid element.
3) test possible fluid flows, classify rotational and irrotational fluid flows .
4) transform stress components from one co-ordinate system to another, establish relation between strain and stress tensor.
5) develop constitutive equations for Newtonian fluids, conservation laws and Navier-Stokes equation.
6) determine the complex potential and images of a two dimensional source, sink and doublet.

Unit I:Physical properties of fluids and kinematics of fluids: concepts of fluids, continuum hypothesis, density, specific weight, specific volume, pressure, viscosity, surface tension, Eulerion & Lagrangian methods of description of fluids, equivalence in Eulerian and Lagrangian methods, general motion of a fluid element, general orthogonal curvilinear co-ordinate system, stream lines, pathlines, streak lines, stream function, vortex lines, circulation, condition at rigid boundary.
15 Lectures

Unit II: Stresses in fluids: Strain rate tensor, stress tensor, normal stress, shearing stress, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor. Newtonian fluids, constitutive equations for Newtonian fluids. **15 Lectures**

Unit III: Conservation laws: equation of conservation of mass, equation of conservation of momentum, Navier-Stokes equation, equation of moment of momentum, equation of energy, Basic equations in different co-ordinate systems: Cartesian co-ordinate system, cylindrical co-ordinate system, spherical co-ordinate system, boundary conditions. **15 Lectures**

Unit IV: Rotational and irrotational flows: Theorems about rotational and irrotational flows: Kelvins minimum energy theorem, Kinetic energy of finite and an infinite fluid, uniqueness of irrotational flows, Bernoullis's equation, Bernoullis equation for irrotational flows, two dimensional irrotational incompressible flows, circle theorem, sources and sinks, sources, sinks and doublets in two dimensional flows, methods of images. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Book(s):

1. R. K. Rathy, An introduction to Fluid Dynamics, Oxford & IBH publishing company.
2. F. Chorlton, Text book of Fluid Dynamics, CHS Publishers, Delhi, 1985.

Reference Books:

1. L. D. Landay and E. M. Lipschitz, Fluid Mechanics, Pergamon Press London 1985.
2. Kundu and Cohen, Fluid Mechanics, Elsevier pub. 2004.
3. L M Milne-Thomson, Theoretical Hydrodynamics, Macmillan Education Ltd, London 1986.

M. A. / M. Sc. Mathematics (Part II) (Level-9) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code: CCS-303, CCS-304, CCS-305, CCS-306
Title of Course: Combinatorics
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. describe Pigeonhole principle and use it to solve problems.
2. use definitions and theorems from memory to construct solutions to problems
3. use Burnside Frobenius Theorem in counting's.
4. use various counting techniques to solve various problems.
5. apply combinatorial ideas to practical problems.
6. improve mathematical verbal communication skills.

Unit I: The sum rule and product rule, permutations and combinations, the Pigeonhole principle, Ramsay numbers, Catalan numbers, sterling numbers. **15 Lectures**

Unit II: Further basic tools, generalized permutations and combinations sequences and selections, the inclusion and exclusion principle, systems of distinct representatives, solved problems derangements and other constrain derangements. **15 Lectures**

Unit III: Combinatorial number theory, the permanent of a matrix, Rook polynomials and Hit polynomials, SDR and coverings, (Sperners theorem and Symmetric chain decomposition, posets and Dilworth's theorem) statements. **15 Lectures**

Unit IV: Generating functions and recurrence relations, ordinary and exponential generating functions, partitions of a positive integer, recurrence relations, algebraic solutions of linear recurrence relations with constant coefficients and solutions of recurrence relations using generating functions. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Books:

1. V. K. Balkrishnan: Combiactorics, Shaums Outlines Series, Mc Grow Hill Inc.

Reference Books:

1. Richard Brualdi – Introductory Combinatosics North Holland.
2. V. Krishnamurthy: Combinatorics, E. W. Press
3. A. Tucker: Combinatorics, John Wiley & Sons, Inc
4. C. Vasudev, Theory and Problems of Combinatorics, New Age International.

M. A. / M. Sc. Part-II (Mathematics) (Level-9)

(Semester IV)(NEP-2020)

Course Code	Title of course
CC-401	Field Theory
DSE-402	1. Integral Equations
CCS-403, CCS-404, CCS-405, CCS-406	1. Quantitative Techniques In Operations Research 2. Fuzzy Mathematics –II 3. Computational Fluid Dynamics 4. Algebraic Number Theory
SEC-407	Fundamentals of Information Technology (FIT)-II
GE-408	

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code:CC-401
Title of Course: Field Theory
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:
1) determine the basis and degree of a field over its subfield.
2) construct splitting field for the given polynomial over the given field.
3) find primitive nth roots of unity and nth cyclotomic polynomial.
4) make use of fundamental theorem of Galois theory and fundamental theorem of Algebra to solve problems in Algebra.
5) apply Galois theory to constructions with straight edge and compass.

Unit I: Algebraic Extensions of fields
Adjunction of roots, Algebraic extensions, Algebraically closed fields. **15 Lectures**

Unit II: Normal and Separable extensions
Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions.
15 Lectures

Unit III: Galois Theory
Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem ofalgebra, Roots of unity and cyclotomic polynomials, Cyclic extensions.
15 Lectures

Unit IV: Applications of Galois Theory
Polynomials solvable by radicals, Symmetric functions, Ruler and compass constructions.
15 Lectures

Seminars, Tutorials, Problem solving session and group discussions onaboveunits.

Recommended Book(s):
1. Bhattacharya, Jain and Nagpaul, Basic Abstract Algebra, second edition, Cambridge University Press.

Reference Books:
1. Joseph Rotman, Galois Theory,second edition, Springer.
2. Nathan Jacobson, Basic Algebra I, second edition, W. H. Freeman and company, New York
3. U. M. Swamy, A. V. S. N. Murthy, Algebra: Abstract and Modern, Pearson Education, 2012
4. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
5. John Fraleigh, A first course in Abstract Algebra (3rd edition) Narosa publishing house, New Delhi
6. I. T. Adamson, Introduction to Field Theory, second edition, Cambridge University Press,1982.
7. M. Artin, Algebra, PHI, 1996.
8. Ian Stewart, Galois Theory, CRC Publication.

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code :DSE-402
Title of Course: Integral Equations
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. classify the linear integral equations and demonstrate the techniques of converting the initial and boundary value problem to integral equations and vice versa.
2. develop the technique to solve the Fredholm integral equations with separable kernel
3. develop and demonstrate the technique of solving integral equation by Successive approximations, using Laplace and Fourier transforms.
4. to analyze the properties of symmetric kernel.
5. to prove Hilbert Schmidt theorem and solve the integral equation by applying it

UNIT– I Classification of linear integral equations, Conversion of initial value problem to Volterra integral equation, Conversion of boundary value problem to Fredholm integral equation, Separable kernel, Fredholm integral equation with separable kernel, Fredholm alternative. Homogeneous Fredholm equations and eigenfunctions. **15 Lectures**

UNIT –II Solutions of Fredholm integral equations by: Successive approximations Method, Successive substitution Method, Adomian decomposition method, Modified decomposition method, Resolvent kernel of Fredholm equations and its properties,Solutions of Volterra integral equations: Successive approximations method, Neumann series, Successive substitution Method.
15 Lectures

UNIT –III Solution of Volterra integral equations by Adomian decomposition method, and the modified decomposition method, Resolvent kernel of Volterra equations and its properties, Convolution type kernels, Applications of Laplace and Fourier transforms to solutions of Volterra integral equations, Symmetric Kernels**:** Fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, expansion in eigenfunctions and bilinear form.
15Lectures

UNIT – IV Hilbert Schmidt Theorem and its consequences, Solution of symmetric integral equations, Operator method in the theory of integral equations, Solution of Volterra and Fredholm integrodifferential equations by Adomian decomposition method, Green's function: Definition, Construction of Green's function and its use in solving boundary value problems. **15Lectures**

Seminars, Tutorials, Problem solving session and group discussions onaboveunits.

Recommended Book(s):

1. R. P. Kanwal, Linear Integral Equation: Theory and Technique, Academic Press, 1971.
2. Abdul-Majid Wazwaz, Linear and Nonlinear Integral Equations**:** Methods and Applications, Springer, 2011

Reference Books:

1. L. G. Chambers, Integral Equations- A Short Course, International Text Book Company, 1976.
2. M. A, Krasnov, et.al. Problems and exercises in Integral equations, Mir Publishers, 1971.
3. J. A. Cochran, The Analysis of Linear Integral Equations, Mc Graw Hill Publications, 1972.
4. C. D. Green, Integral Equation Methods, Thomas Nelson and sons, 1969.

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code: CCS-303, CCS-304, CCS-305, CCS-306
Title of Course: Quantitative Techniques in Operations Research
Total Credits : 04

Course Outcome-: Upon successful completion of this course, the student will be able to :-

1. decide policy for replacement.
2. calculate economic lot size.
3. derive Poisson distribution theorem and compute attributes of distribution model.
4. identify optimal path by using CPM and PERT.

Unit I : Replacement problems: failure mechanism of items, replacement policy for items whose maintenance cost increases with time and money value is constant, Money value, Present worth Factor (PWF) and Discount rate, replacement policy for items whose maintenance cost increases with time and money value changes with constant rate, individual replacement policy. Group replacement of items that fail completely (suddenly). **15 Lectures**

Unit II : Inventory : cost involved in inventory problems, variables in inventory problem, symbols in inventory, concept of Economic Ordering Quantity (EOQ), Model I (a) The economic lot size system with uniform demand, Model I (b) The economic lot size with different rates of demand in different cycles, Model I (c) The economic lot size with finite rate of replenishment ,(EOQ production model) EOQ model with shortages, Model II (a) The EOQ with constant rate of demand , scheduling , time constant. Model II (b) The EOQ with constant rate of demand, scheduling, time variable. Model II (c) The production lot size model with shortages. **15 Lectures**

Unit III : Queuing theory: Queuing systems, queuing problems, transient and steady states. traffic intensity, probability distributions in queuing system, Poisson process, properties, exponential process , classification of queuing models , Model I : (M/M/I) : (infinity / FCFS) Model II (a) : General Erlang Queuing model . **15 Lectures**

Unit IV : Project Management By PERT / CPM : Introduction. Basic steps in PERT / CPM techniques. Network Diagram Representation. Rules for Drawing Network Diagram. Time Estimates and Critical Path in Network Analysis. Determination of Critical Path. Applications Areas of PERT / CPM.

15 Lectures

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Books :

1.S.D. Sharma : Operations Research , Kedar Nath Ram Nath and Co.
2.J K Sharma: Operations Research : Theory and Applications, Mac Millan Co.

Reference Books :

1. Kanti Swarup, P. K. Gupta and Manmohan : Operations Research , S. Chand & Co.
2. Hamady Taha : Operations Research : Mac Millan Co.
3. S. D. Sharma: Linear Programming, Kedar Nath Ram Nath and Co.
4. S. D. Sharma : Nonlinear and Dynamic programming Kedar Nath Ram Nath and Co. Meerut.
5. R. K. Gupta : Operations Research, Krishna Prakashan Mandir, Meerut.

M. A. / M. Sc. Part-II (Mathematics) (Level-9) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code:CCS-403, CCS-404, CCS-405, CCS-406
Title of Course: Fuzzy Mathematics-II
Total Credits: 04

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. acquire the concept of fuzzy relations.
2. understand the basic concepts of fuzzy logic.
3. develop the skills of solving fuzzy relation equations.
4. construct approximate solutions of fuzzy relation equations.
5. solve problems in Engineering and medicine.

Unit I : Projections and cylindrical extensions, binary fuzzy relations on single set, fuzzy equivalence relations, fuzzy compatibility relations, fuzzy ordering relations, fuzzy morphisms sup-i composition and inf-wi composition. **25 Lectures**

Unit II: Fuzzy relation equations, problem partitioning, solution methods, fuzzy relational equations based on sup-i and inf-wi compositions, approximate solutions. **15 Lectures**

Unit III : Fuzzy propositions, fuzzy quantifiers, linguistic edges, inference from conditional fuzzy propositions, qualified and quantified propositions. **10 Lectures**

Unit IV: Approximate reasoning : fuzzy expert systems, fuzzy implications, selection of fuzzy implications, multi-conditional approximate reasoning, the role of fuzzy relation equations, internal valued approximate reasoning. **10Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Books:

1. George J Klir, BoYuan, Fuzzy Sets and Fuzzy Logic: Theory and applications, PHI. Ltd.(2000)

Reference Books:

1. M. Grabish, Sugeno, and Murofushi, Fuzzy Measures and Integrals: Theory and Applications PHI, 1999.
2.H. J. Zimmerermann, Fuzzy set: Theory and its Applications, Kluwer,1984.
3.M. Ganesh, Introduction to Fuzzy sets & Fuzzy Logic; PHIL earning Private Limited, New Delhi. 2011.
4. John Mordeson, Fuzzy Mathematics, Springer,2001

M.A./M. Sc. (Mathematics) (Part II) (Semester III)
(NEP-2020)
(Introduced from June 2023 onwards)

Course Code: CCS-403,CCS-404,CCS-405, CCS-406
Title of Course: Computational Fluid Dynamics

Course Outcomes: Upon successful completion of this course, the student will be able to:
1. classify partial differential equations (PDEs) mathematically and physically.
2. apply separation of variables method for solving initial boundary value problems.
3. construct forward, backward and centered difference formulae.
4. test stability, convergence & consistency of finite difference schemes.
5. solve problems in CFD using Scilab software.

Unit I: Comparison of experimental, theoretical and numerical approaches, governing equations, continuity equation, momentum equation (inviscid, viscous flows) energy equation, incompressible viscous flow, laminar boundarylayer flow. Introduction of Scilab to solve problems in CFD.
15 Lectures

Unit II: Nature of a well posed problems, physical classification and mathematical classification of partial differential equations: hyperbolic, parabolic, elliptic partial differential equations (PDEs). Conversion of PDE to canonical form. Traditional solution method: separation of variables, transformation relationships, evaluation of transformation parameters, forward, backward, centered difference formulae, generalized co-ordinates structure of first and second order PDE.**15 Lectures**

Unit III: Stability, convergence and consistency of finite difference scheme, Explicit, Implicit and Crank- Nicolson methods for heat equation, Von Neumann analysis, Euler's explicit method, upstream differencing method, Laxmethod, Euler implicit method for wave equation. Finite difference representation of Laplace equation, five point method. Problem solving by Scilab: codes of explicit methods for heat and wave equations and five point method for Laplace equation.
15 Lectures

Unit IV: Finite difference schemes for Burgers equation (inviscid): Lax method, implicit methods. Finite difference schemes for Burgers equation (viscous): FTCS method, Briley – Mc Donald method. convergence and stability, grid generation, orthogonal gird generation, order of magnitude analysis, Reduced Navier-Stokes equations, boundary layer flow. **15 Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Book(s):

1. Dale A Anderson, John Tannelhill, R. H. Fletcher, Computational Fluid Mechanics and Heat Transfer, Hemisphere publishing corporation, 1984.
2. G D Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Oxford Applied Mathematics and Computing Science Series, Oxford University Press, 1985.
3. C. A.J. Fletcher, Computational Techniques for Fluid Dynamics Vol. I & II, Springer Verlag Berlin Heidelberg, 1988.

Reference Books:

1. T J Chung, Computational Fluid Dynamics, Cambridge University Press, 2002.

M. A. / M. Sc. Mathematics (Part II) (Level-9) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2023-24)

Course Code:CCS-403, CCS-404, CCS-405, CCS-406
Title of Course: Algebraic Number Theory
Total Credits:04

Course Outcomes: Upon successful completion of this course, the student will be able to

1. deal with algebraic numbers, algebraic integers and its applications,
2. concept of lattices and geometric representation of algebraic numbers.
3. understand the concept of fractional ideals.
4. relate finitely generated abelian groups and modules
5. derive Minkowski's theorem.
6. compute class groups and class numbers.

Unit I: Revision of ring and fields, factorization of polynomials and field extensions. Symmetric polynomials, modules, free abelian groups, algebraic numbers, conjugates and discriminates.
15Lectures

Unit II: Integral bases, norms and traces, rings of integers. Quadratic and cyclotomic fields. Trivial factorization, factorization into irreducibles, examples of non-unique factorization into irreducibles, prime factorization, Euclidean domains, Euclidean quadratic fields. **15Lectures**

Unit III: Prime factorization of ideals, the norm of an ideal, non-unique factorization in cyclotomic fields. Lattices, the quotient torus, Minkowski's theorem, the two-square theorem, the four-square theorem. **15Lectures**

Unit IV: Geometric Representation of algebraic numbers. The class group, Existence theorem, finiteness of the class group. Factorization of a rational prime, Minkowski's constants, some class number calculations, tables. **15Lectures**

Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Books:

1. I. N. Stewartand D. O. Tall, Algebraic Number Theory and Fermat's Last Theorem, 2015, CRC press.

Reference Books:

1. Algebraic Number Theory: Mathematical Pamphlet, TIFR, Bombay.
2. N. Jacobson, Basic Algebra-I, Hindustan Publishing Corporation(India),Delhi(Unit-I)
3. Paulo Ribenboim, Classical Theory of Algebraic Numbers, Springer, New York(2001).
4. N. S. Gopalkrishnan, University Algebra, New Age International (P) Ltd. Publishers.
5. Ian Stewart, Galoi Theory, CRC press(2015).
6. Harry Pollard, The Theory of Algebraic Numbers, The Mathematical Association of America.