Vidyasagar University

Applied Mathematics with Oceanology and Computer Programming
Midnapore-721 102, West Bengal
Syllabus of M.Sc.

With effect from 2007-2008.

Semester-I

Course No.	*Topics*	*Marks*
MA1101	Real Analysis	50
MA1102	Complex Analysis	50
MA1103	Ordinary Differential Equations and Special Functions	50
MA1104	Introduction to Computing	50
MA1105	Classical Mechanics	50
MA1106	Graph Theory	25
MA1111	Lab. 1: (Application Softwares and use of Internet)	25

Semester-II

Course No.	*Topics*	*Marks*
MA1201	Fluid Mechanics	50
MA1202	Numerical Analysis	50
MA1203 Gr.-A	Abstract Algebra	25
MA1203 Gr.-B	Linear Algebra	25
MA1204	Continuum Mechanics	50
MA1205	Functional Analysis	50
MA1206	Stochastic Process and Regression	25
MA1211	Lab. 2: (Programming Languages Lab.)	25

Semester-III

Course No.	*Topics*	*Marks*
MA2101	Partial Differential Equations	50
MA2102	Integral Transforms and Integral Equations	50
MA2103	Operations Research /Dynamical Oceanology and Meteorology	50
MA2104	Object Oriented Programming with C++	25
MA2105	Special Paper-OM Dynamical Oceanology-I	50
MA2106	Special Paper-OM Dynamical Meteorology -I	50
MA2105	Special Paper-OR Advanced Optimization and Operations Research	50
MA2106	Special Paper-OR Operational Research Modelling-I	50
MA2111	Lab. 3: (Advanced Numerical and Statistical Lab.)	25

Semester-IV

Course No.	*Topics*	*Marks*
MA2201 Gr. A	Topology	25
MA2201 Gr. B	Data Structure and Design and Analysis of Algorithms	25
MA2202 Gr. A	Differential Geometry	25
MA2202 Gr. B	Magneto Hydro-Dynamics	25
MA2203 Gr. A	Fuzzy Sets and their Applications	25
MA2203 Gr. B	Soft Computing / Gas Dynamics	25
MA2204	Special Paper-OM Dynamical Oceanology -II	50
MA2205	Special Paper-OM Dynamical Meteorology -II	25
MA2204	Special Paper-OR Nonlinear Optimization	50
MA2205	Special Paper-OR Operational Research Modelling-II	25
MA2206	Grand Viva	25
MA2211	Lab. 4: (Data Base Management System and Software Development)	25
MA2212	Lab. 5: (Lab. on Special Paper)	25

Semester-I

MA1101 Real Analysis 50

Function of bounded variation and its simple properties. Total variation and its additive property. Variation function and its properties. Necessary and sufficient conditions for a function to be bounded variation.

Riemann Stieltjes integrals: Definition as limit of a sum. Its properties. R-S integrals with monotonic integrators. First and second mean value theorems. R-S integrals with function of bounded variation as integrator. Reduction of R-S integrals to a Riemann integral. R-S integral with step function as integrator. Euler's summation formula. Differentiation under the integral sign. Multiple integral. Interchanging the order of integration.

Measurable sets. Concept of Lebesgue measure. Inner and outer measure. Its simple properties. Set of measure zero. Cantor set.

Measurable function : Definition. Modulus of measurable function is measurable. Every continuous function is measurable. Sum. difference. product and quitient of measurable functions are measurable. Statements of Lusin and Egoroff's Theorems.

Lebesgue integral: Definition. Basic simple properties. Relation between Lebesgue integral and Riemann integral. Lebesgue integral of a bounded function over a set A of finite measure. Simple properties. Lebesgue integral for unbounded functions. Bounded convergence theorem for a sequence of function. Fatou's lemma. Classical Lebesgue dominated convergence theorem. Monotone convergence theorem.

MA1102 Complex Analysis 50

Complex numbers. The complex plane. Functions of a complex variable. Limit. Continuity. Differentiability. The definition of an analytic function. Cauchy- Riemann differential equation. Construction of analytic function.

Complex integration. Jardan arc. Contour. Rectifiable arcs. The absolute value of complex integral. Cauchy's theorem. Cauchy's integral formula. The derivatives of an analytic function. Cauchy's inequality. Morer's theorem. Liouville's theorem. Taylor's and Laurent's series. Maximum modulus principle.

Singularities : Zero of an analytic function. Different types of singularities. Poles. Isolated. Removal and Essential singularities.

Residues: Residue at pole. Residue at infinity. Cauchy residue theorem. Number of poles and zeros of an analytic function. Rouche's theorem.

Contour integration: Evaluation of integrals using contour integration.

Conformal representation: Conformal transformation. Mobius transformation or Bilinear transformation. Mapping properties of important functions.

MA1103 Ordinary Differential Equations and Special Functions 50

Differential equation. Homogeneous linear differential equations. Fundamental system of integrals. Singularity of a linear differential equation. Solution in the neighbourhood of a singularity. Regular integral. equation of Fuchsian type. Series solution by Frobenius method.

Hypergeometric equation. Hypergeometric functions. Series solution near zero. one and infinity. Integral formula for the hypergeometric function. Differentiation of hypergeometric function. The confluent hypergeometric function. Integral representation of confluent hypergeometric function.

Legendre equation: Legendre functions, Generating function, Legendre functions of the first kind and second kind, Laplace integral, Orthogonal properties of Legendre polynomials, Rodrigue's formula, Schlaefli's integral.

Bessel equation: Bessel function, Series solution of Bessel equation, Generating function, Integrals representations of Bessel's functions, Hankel functions, Recurrence relations, Asymptotic expansion of Bessel functions.

Green's Function: Green's Function and its properties, Green's function for ordinary differential equations , Application to Boundary Value Problems.

Eigen Value Problem: Ordinary differential equations of the Strum Liouville type, Properties of Strum Liouville type, Application to Boundary Value Problems. Eigenvalues and eigen-functions, Orthogonality theorem, Expansion theorem .

System of Linear Differential Equations: Systems of First order equations and the Matrix form, Representation of nth order equations as a system, Existence and uniqueness of solutions of system of equations, Wronskian of vector functions.

MA1104 Introduction to Computing 50

Digital Technique

Data Representation: Binary coded decimal number, Gray code, Alphanumeric Code, Error detection and correction code, Hamming Error-Correction code.

Number system and their arithmetic operation. Complement representation of numbers. Signed numbers in complement forms, Addition/subtraction in one's and two's complement notation, Arithmetic with BCD number, Floating point numbers, its addition/subtraction.

Algebra for digital system: Logic gates, Simplifying Boolean expressions by Veitch-Karnaugh map method.

Combinational switching circuit: Its design procedure, implementing combinational logic circuit.

Programming in C and Fortran

C: Introduction, basic structure, character set, keywords, identifiers, variable, constants, variable-type declaration, operators and expressions, operator precedence and associativity, expression evaluation, type conversion, comma operator, compound statement, type def statement, assignment statement, input and output statements, branching statements, looping statements, break and continue statement, user defined functions, recursion, scope and extent, arrays, pointers, strings and string handling functions, structure and union, pointers, file handling functions.

Fortran: Introduction, basic structure, character set, keywords, identifiers, variable, constants, variable-type declaration, operators and expressions, operator precedence and associativity, expression evaluation, type conversion, compound statement, assignment statement, input and output statements (formatted and unformatted), branching statements, looping statements, statement, user defined functions, arrays, strings manipulation, files.

MA1105 Classical Mechanics 50

System of particles: Linear momentum. Angular momentum. Conservative forces. Conservation of linear momentum. Angular momentum and total energy. Virial theorem.

Orientation and displacement of a rigid body. Angular velocity. Eulerian angles. Infinitesimal rotations Coriolis acceleration. Moving axes. Motion relative to rotating Earth. A brief review of orbital mechanics with special reference to satellite mechanics. Faucault's pendulum Inertial tensor and moment of inertia. Angular momentum and Kinetic energy. Eular's dynamical equations and torque free motion of rigid body about a fixed point on it.

Generalized coordinates. Constraints. Holonomic and non-holonomic system. principle of Virtual work. D'Alembart's Principle. Lagrange's equations for holonomic(conservative and non-conservative forces) and non-holonomic systems. Generalized momenta. Cyclic co-ordinates. Routh's procedure. Hamilton's canonical equations. Motion of a symmetrical top with one point fixed.

Variational principle. Brachistocrone problem. Hamilton's principle. Principle of least action. Deduction of Lagrange and Hamilton equation from Hamilton's principle. Legendre transformation. Canonical transformation. Hamilton-Jacobi equation for Hamilton's principle function. Solution of harmonic oscillator problem by Hamilton-Jacobi method. Liouville's theorem. Poisson brackets.

Small oscillation about equilibrium. Lagrange's method. Normal co-ordinates. Oscillations under constraint. Stationary character of a normal mode. Small oscillation about the state of steady motion. Vibration of strings.

Special theory of relativity in Classical Mechanics:-Postulates of special relativity. Lorentz transformation. Consequences of Lorentz transformation. Force and energy equations in relativistic mechanics.

MA1106 Graph Theory 25

Elements of graph theory. Eularian and Hamiltonian Graphs. Trees. Planar graphs. Distance and centre. Duals. Cut sets and cut vertices. Bipartite graphs. Colouring and matching. Four colour theorem (statement only). Planar graphs. Directed graphs and weighted graphs. Matrix representation of graphs. Applications of graphs in operations research, chemistry, planning, biological sciences, etc.

MA1111 Lab. 1: (Application Softwares and Use of Internet) 25

Problem: 20 marks; Lab. note book and viva: 5.

Basic operations on WINDOWS and UNIX operating systems.
MS-WORD, MS-EXCEL, MS-POWER POINT.
Use of Internet: E-mail, Net searching.

Semester-II

MA1201 Fluid Mechanics 50

Irrotational Motion in Two Dimensions: General motion of a cylinder in two dimensions. Motion of a cylinder in a uniform stream, Liquid streaming past a fixed circular cylinder and two coaxial cylinders. Equations of motion of a circular cylinder. Circulation about a moving cylinder. Conjugate function. Elliptic cylinder. Liquid streaming past a fixed elliptic cylinder. Elliptic cylinder rotating in an infinite mass of liquid at rest at infinity. Circulation about an elliptic cylinder. Kinetic energy. Blasius theorem and its application. Kutta and Joukowski theorem, D'Alemberts paradox. Application of conformal mapping.

Vortex Motion: Vortex line, Vortex tube, Properties of the vortex, Strength of the vortex, Rectilinear vortices, Velocity component, centre of vortices. A case of two vortex filaments, vortex pair. Vortex doublet. Image of vortex filament with respect to a plane. An infinite single row of parallel rectilinear vortices of same strength. Two infinite row of parallel rectilinear vortices, Karman's vortex street. Rectilinear vortex with circular section. Rankine's combine vortex. Rectilinear vortices with elliptic section.

Viscous Flow: Navier-Stokes equations, Vorticity and circulation in viscous fluids. Reynolds number, Boundary conditions, Flow of a viscous fluid with free surface on an inclined plane. Flow between parallel plates. Flow through pipes of circular, elliptic section under constant pressure gradient. Laminar flow between concentric rotating cylinder. Steady motion of a viscous fluid due to a slowly rotating sphere. Unsteady motion of a flat plate. Pulsatile flow between parallel surfaces. Prandtl's concept of boundary layer. Boundary layer flow along a flat plate. Momentum and energy integral equation for the boundary layer. Von Karman Pohlhousen method. Turbulence, Calculation of Turbulent BL.

MA1202 Numerical Analysis 50

Symbolic operators and their relations.

Interpolation: Central difference formulae of Gauss, Stirling, Bessel. Aitken's iteration method. Inverse interpolation. Cubic spline interpolation. Lagrange's bivariate interpolation. Approximation of function. Chebyshev polynomial: Minimax property. Curve fitting by least square method. Use of orthogonal polynomials. Economization of power series.

Numerical integration: Newton-Cotes formulae-open type. Gaussian quadrature: Gauss-Legendre, Gauss-Chebyshev. Romberg integration. Integration by Monte Carlo method.

Roots of polynomial equation: Birge-Vieta method. Graeffe's root squaring method. Solution of a system of non-linear equations by fixed point method and Newton-Raphson methods. Convergence and rate of convergence.

Solution of a system of linear equations: Matrix inverse. LU decomposition method. Solution of tri-diagonal system of equations. Ill-conditioned linear systems. Relaxation method.

Eigenvalue problem. Power method. Jacobi's method.

Solution of ordinary differential equation: Runge-Kutta method to solve a system of equations and second order IVP. Predictor-corrector method: Milne's method.

Stability. Solution of second order boundary value problem by finite difference and finite element methods.

Partial differential equation: Finite difference scheme. Parabolic equation: Crank-Nicolson method. Iteration method to solve Elliptic and hyperbolic equations.

MA1203 Abstract Algebra 25
Gr-A

Groups: Morphism of groups. Quotient groups. Fundamental theorem on homomorphism of groups. Isomorphism theorems. Automorphism. Solvable groups and theorems on them. Direct product. Conjugacy. Conjugate classes. Class equation. Theorems on finite groups. Cauchy's theorem. Sylow's theorem. Application of Sylow's theorem, Simple groups, Permutation groups, Cayley theorem, Group actions.

Rings and Field: Integral domain. Fields. Skew fields. Quotient rings. Morphism of rings. Ideals (Prime and maximal). Isomorphism theorem. Euclidean domain. Principal ideal domain. Unique factorization domain. Polynomial rings.

MA1203 Linear Algebra 25
Gr-B

Linear Transformation: The algebra of linear transformations, Kernel, Range, Isormorphism, Rank and Nullity, Matrix representation of a linear transformation, Linear operator, Linear functions.

Inner product space, Dual space, Projections, Gram-Schimdt orthogonolisation.

Lattice: Partially and totally ordered set, Lattice, Complete Lattice, Distributive Lattice, Complements.

MA1204 Continuum Mechanics 50

Stress: Body force. Surface forces. Cauchy's stress principle. Stress vector. State of stress at a point. Stress tensor. The stress vector –stress tensor relationship. Force and moment equilibrium. Stress tensor symmetry stress quadric of Cauchy. Stress transformation laws. Principal stress. Stress invariant. Stress ellipsoid.

Strain: Deformation Gradients. Displacement Gradient Deformation tensor. Finite strain tensors. Small deformation theory-infinitesimal strain tensor. Relative displacement. Linear rotation tensor. Interpretation of the linear strain tensors. Strength
ratio. Finite strain interpretation. Principal strains. Strain invariant. Cubical dilatation .
Compatibility equation for linear strain. Strain energy function. Hook's law. Saint –Venant's principal. Airy's strain function.

Isotropic media. Elastic constrains. Moduli of elasticity of isotropic bodies and their relation. Displacement equation of motion.

Waves in isotropic elastic media.

Perfect fluid. Kinematics of fluid. Lagrangian method.. Eulerian method. Acceleration . Equation of continuity. The boundary surface.. Stream lines and path lines. Irrotational motion

and its physical interpretation. Velocity potential. Euler's equation of motion of an in viscid fluid. Cauchy's integral. Bernoulli's equation. Integration of Euler's equation.
Impulsive motion of fluid. Energy equation. Motion in two dimensions. The stream functions Complex potential. Source, sink and doublet and their images. Milne-Thompson circle theorem and its application. Vorticity. Flow and circulation. Kelvin's circulation theorem. Kelvin's minimum energy theorem.

MA1205 Functional Analysis 50

Compact metric spaces. Total boundedness. Equi-continuous family of functions. Ascoli-Arzela's theorem. Separable and non-separable metric spaces. Contraction mapping. Banach fixed point theorem. Its application to find solution of a system of algebraic linear. differential and integral equation.

Linear metric space. Examples. Normed linear spaces. Examples. Norm is continuous operator. A NLS is complete iff every absolutely convergent series is convergent.

Bounded linear transformation. Set of all bounded linear transformation B(X.Y) from NLS X into NLS Y is a NLS. B(X.Y) is a Banach space if Y is a Banach space. Statement of Hahn-Banach theorem. Theorems obtained as application of Hahn-Banach thorem. Open mapping theorem. Closed Graph Thorem. Banach Steinhaus theorem.

Inner product space and Hilbert space. Projection theorem. Cauchy-Schwarz inequality. Inner product is a continuous operator. Relation between IPS and NLS. Definition of uniformly convex space. Every IPS is uniformly convex. Pythogorian theorem for n vectors. Gram-Schmidt orthogonalisation process. Bessel's inequality. Parseval's identity. Reisz representation theorem for bounded linear functional on a Hilbert space. Definition of Normal. Unitary and Positive operators. Related simple theorem

Elementary calculus in Banach spaces: Gateaux and Frechet derivative in Banach spaces. Integration in Banach spaces.

MA1206 Stochastic Processes and Regression 25

Stochastic Process: Markov chains with finite and countable state space. Classification of states. Limiting behavior of *n* state transition probabilities. Stationary distribution. Branching process. Random walk. Gambler's ruin problem. Markov processes in continuous time. Poisson's process Partial correlation. Multiple correlation. Advanced theory of linear estimation.

MA1211 Lab. 2: (Programming Languages Lab.) 25

Problem: 20 marks; Lab. note book and viva: 5.

The programs are to be written to solve the following problem using Fortran 77 and C languages.

(a) On Numerical Problems:

(i) Solution of an equation $f(x)=0$ by Bisection, Iteration, Regula False, Newton Raphson methods.

(ii) Evaluation of polynomial by Horner's method.

(b) On Statistical Problems:

(i) Preparation of Frequency table, Histogram

(ii) Problems on simple frequency distribution: Mean, Median, Mode, Quartile, Standard deviation, Moments, Skewness, Kurtosis, Beta, Gamma coefficient

(iii) Problems on group distribution: Mean, S.D., Median, Mode, Quartile, Percentiles

(iv) On bivariate distribution: correlation coefficient, Regression lines, Curve fitting

(c) On Searching and Sorting Problems:

(i) Linear and binary search

(ii) Sorting: Bubble, Insertion, Selection techniques.

(d) String manipulation

(i) No of occurrence of a letter in a given string

(ii) Palindrome nature of string

(iii) Rewrite the name with surname first

(iv) Print a string in a reverse order

(v) String searching

(vi) Sorting of names in alphabetic order

(vii) Find and replace a given letter or word in a given string

(viii) Combinations of letters of a word

(ix) Conversion of name into abbreviation form

(x) Pattern matching

(e) Miscellaneous Problems:

(i) Generation of random numbers

(ii) Generation of prime numbers

(iii) Generation of Fibonacci numbers

(iv) Graph plotting

(v) Multiple choice test

(vi) Multiplication of polynomials

(vii) Addition, subtraction, transpose, inverse, multiplication of matrices

(viii) Determination of determinant

(ix) Preparation of calendar

(x) Nature and roots of Quadratic equation

(xi) Checking of divisibility

(xii) Splitting of numbers

(xiii) Summation of Series

(xiv) Conversion among decimal, binary, octal, Hexadecimal

Semester-III

MA2101 Partial Differential Equations 50

Partial Differential Equation:

The existence theorem of Cauchy and Kowalewsky. Methods of solving first order linear and non-linear equations and higher order linear equations with constant coefficients.

Equation of second order:

Reduction to canonical forms of linear and quasi-linear equations of second order in two independent variables and classification of equations. characteristic curves. Adjoint equation Self-adjoint equations. canonical forms and classification of second order linear equations in many independent variables.

Linear partial differential equations with constant coefficients: Green's Function construction with the help of delta function.

Hyperbolic equations:

The equation of vibration of a string. Formulation of the mixed initial and boundary value problem. Existence. uniqueness and continuous dependence of the solution on the initial conditions. D'Alembert's formula for the vibration of an infinite string. The domain of dependence. the domain of influence. Method of Separation of variables. Investigation of the conditions under which series converges and represent the solution. Riemann- Volterra method of solution. Goursat's problem for one dimensional wave equation.

Elliptic equations:

Occurrence of Laplace's equation. the fundamental solution of Laplace's equations in two and three independent variables. Harmonic function. regularity. characterization of harmonic function by their mean value property. Uniqueness. Continuous dependence and existence of solutions. Method of separation of variables for the solutions of Laplace's equations in two and three dimensions. Dirichlet's and Naumann's problems. Dirichlet's principles. Green's functions for the Laplace's equations in two and three dimensions. Solution of Dirichlet's and Naumann's problem for a disc. half-space and a sphere. The potentials due to a volume distribution. a single layer and a double layer. Representation of a Harmonic function by potentials of simple and double layers. Poisson's general solution.

Parabolic equations:

Diffusion equation. Conduction of Heat in a bounded strip (First boundary value problem). uniqueness. continuous dependence and existence of solution. Conduction of heat in an infinite strip (Cauchy problem) . Method of separation of variables.

MA2102 Integral Transforms and Integral Equations 50

Laplace Transform: Laplace transform, Properties of Laplace transform, Inversion formula of Laplace transform(Bromwich formula), Convolution theorem, Application to ordinary and partial differential equations.

Fourier Transform: Properties of Fourier transform, Inversion formula, Convolution, Parseval's relation, Multiple Fourier transform, Bessel's inequality, Application of transform to Heat, Wave and Laplace equations.

Hankel Transform: Hankel transform, Inversion formula of Hankel transform, Parseval relation, Finite Hankel transform, Application to Partial differential equations

Mellin's Transform: Properties of Mellin's transform. Inversion theorem, Convolution theorem, Application of Mellin' s transform.

Integral Equation: Formulation of integral equations, Integral equations of Fredholm and Volterra type, solution by successive substitutions and successive approximations. Resolvent Kernel Method. Integral equations with degenarate kernels. Abel's integral equation, Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems. Integral equations with symmetric kernel, Eigenvalue and eigenfunction of integral equation and their simple properties. Fredholm alternative.

Generalised Function : Good function and Fairly good function and their properties, Regular Sequences, Generalised functions, Properties of generalised function, Dirac's delta function, Heaviside unit function and Signum function, Derivative of generalised function, Fourier transform of generalized functions.

MA2103 Operations Research /Dynamical Oceanography and Meteorology 50

Either

(For the student whose special paper is OM)

Elements of Optimization and Operations Research. (OR)

Revised simplex method (with and without artificial variables), Post optimality analysis : Change in the objective function, change in the requirement vector, addition of a variable, addition of a constraint.

Classical optimization techniques : Single variable optimization, multivariate optimization (with no constraint, with equality constraints and with inequality constraints).

Integer programming : Gomory's cutting plane algorithm, (Gomory's mixed integer program algorithm) A branch and bound algorithm,

Optimal Control : Methods of calculus of variations, simple optimal problems of mechanics. Inventory model (deterministic).

Non-linear Programming : Quadratic Programming : Wolf's modified simplex method and Beale's method.

Convex programming. Dynamic programming. Decomposition principle due to Dantzig and Wolfe.

Or

(For the student whose special paper is OR)

Dynamical Oceanology and Meteorology (OM)

Dynamical Oceanology: Navier-Stokes equations of motion for viscous fluid. Thermodynamics of sea-water in equilibrium state. Salinity. Basic thermodynamics. Gibb's general thermodynamics relation for sea-water. Governing equations of motion of sea water. Boundary conditions at the free ocean surface. Linearised equation of small amplitude oceanian wave motion on a rotating earth. Boussinesq approximation. The beta plane approximation, Equation of conservation of energy for linearised wave motion.

Dynamical Meteorology: Heat balance of the atmosphere, Basic thermodynamics of the atmosphere. Potential temperature and stability of dry air.

Energy in a compressible atmosphere, change in potential energy due to adiabatic interchange of small parcels, dissipation of energy.

General circulation, its schematic description and theory (in out line).

Rate of change of circulation. Geostrophic and thermal wind. The geostrophic balance, The geodynamical paradox. Surface of discontinuity. Classification of fronts. Formation of cyclones. Aerological diagrams, its purpose and use.

MA2104 Object Oriented Programming with C++ 25

Introduction to object-oriented programming paradigm and design. Object. Classes and scope, nested classes, pointer class members. Class initialization, constructor and destructor. Overloaded function and operators. Templates including class templates. Inheritance: multiple and virtual inheritance.

MA2105 Special Paper-OM 50
Dynamical Oceanology-I

Thermodynamics of Equilibrium State: Gibb's relation, Thermodynamic potentials. Definition of Salinity, Sea water as two component mixture, Entropy, Internal energy and Chemical potential of sea water, Adiabatic gradient of temperature and coefficient of compressibility of sea water, equilibrium conditions of sea water.

Thermodynamics of Irreversible Processes : Fluxes of heat and salt, conservation equations for heat, salt and mass, Navier-Stokes equations in an inertial frame and the corresponding equation in a uniformly rotating frame. Potential Vorticity. The- plane approximation. Boussinesq approximation,

Basic concept of turbulence, Reynold's stresses, equation of turbulent energy, Coefficient of turbulent exchange. Closer of the system of average equation for the large scale flow, Boundary conditions, Ageostrophic motion, Ekman layer on a free surface, Vertical Shear layers.

MA2106 Special Paper-OM 50
Dynamical Meteorology-I

Thermodynamics of Real Atmosphere: Basic laws of thermodynamics, potential temperature, Lapserate. Atmospheric water vapour. Equation of state for Dry and Moist air, Dry weather, virtual Temperature, Adiabatic changes in unsaturated Moist Air and in saturated Moist Air, Pseudoadiabatic change, Equivalent Temperature and Equivalent Potential Temperature, Saturated adiabatic Lapse Rate, Stability in saturated adiabatic changes, conditional Instability, Isobaric Cooling, Condensations by Isobaric cooling.

Aerological Diagrams: Purpose and use of Aerological Diagrams, Clapeyron and Refsdal and Stuve diagrams, Tephigram, Emagram , Area equivalence. Compositions and structure of the Atmosphere**.** Solar and Terristrial radiations. Derivation of the complete of thermo-Hydrodynamical equation w.r.t. the Rotating Earth, Energy and Angular Momentum, Circulation and vorticity, Rate of change of circulation, The geostrophic gradient, Thermal and cyclostrophic winds, The geodynamical Paradox, Steady motion along a circular Isobar, accelerated motion and a changing pressure field, Divergence, Convergence and pressure variation, Pressure distribution in a moving cyclone, Pressure-tendency equation, The atmospheric energy equation, The dissipation of energy, Available potential energy.

The general circulation and monsoon meteorology Atmospheric wave, Numerical wave prediction,

MA2105 Special Paper-OR 50

Advanced Optimization and Operations Research

Revised simplex method (with and without artificial variable). Modified dual simplex .

Parametric and post-optimal analysis: Change in the objective function. Change in the requirement vector, Addition of a variable, Addition of a constraint, Parametric analysis of cost and requirement vector.

Classical Optimization Techniques: Multivariate optimization (with no constraint, with equality constraints and with inequality constraints)

Unconstrained optimization :

Search Methods: Fibonacci and golden section method.

Gradient Method: Method of conjugate directions for quadratic function, Streepest descent and Davodon-Fletcher-Powell method.

Constrained Optimization : Methods of feasible direction and cutting hyperplane method.

Integer Programming: Gomory's cutting plane algorithm, Gomory's mixed integer problem algorithm, A branch and bound algorithm.

Goal Programming: Introduction, Difference between LP and GP approach, Concept of Goal Programming, Graphical solution-method of Goal Programming, Modified simplex method of Goal Programming.

MA2106 Special Paper-OR 50

Operational Research Modelling-I

Dynamic Programming: Introduction, Nature of dynamic programming, Deterministic processes, Non-Sequential discrete optimization, Allocation problems, Assortment problems, Sequential discrete optimization, Long-term planning problem, Multi-stage decision process, Application of Dynamic Programming in production scheduling and routing problems.

Inventory control : Inventory control -Deterministic including price breaks and Multi-item with constraints , -Probabilistic (with and without lead time), Fuzzy and Dynamic inventory models.

Queuing Theory : Basic Structures of queuing models, Poisson queues –M/M/1, M/M/C for finite and infinite queue length, Non-Poisson queue -M/G/1, Machine-Maintenance (steady state).

Network : PERT and CPM: Introduction, Basic difference between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM Network components and precedence relationships, Critical path analysis, Probability in PERT analysis, Project Time-Cost, Trade-off, Updating of the project, Resource allocation — resource smoothing and resource leveling.

Replacement and Maintenance Models: Introduction, Failure Mechanism of items, Replacement of items deteriorates with time, Replacement policy for equipments when value of money changes with constant rate during the period, Replacement of items that fail completely— individual replacement policy and group replacement policy, Other replacement problems — staffing problem, equipment renewal problem.

Simulation: Introduction, Steps of simulation process, Advantages and disadvantages of simulation, Stochastic simulation and random numbers— Monte Carlo simulation, Random

number, Generation, Simulation of Inventory Problems, Simulation of Queuing problems, Role of computers in Simulation, Applications of Simulations.

MA2111 Lab. 3: (Advanced Numerical and Statistical Lab.) 25

Problem: 20 marks; Lab. note book and viva: 5.

On Numerical Problems:

(i) Evaluation of determinant by Gauss elimination method, using partial pivoting.
(ii) Matrix inverse by partial pivoting.
(iii) Roots of Polynomial equation.
(iv) Solution of system of linear equations by Gauss Seidal iteration method, Matrix inversion method, LU decomposition method, Gauss elimination method.
(v) Solution of Tri-diagonal equations.
(vi) Interpolation: Difference table, Lagrange, Newton forward and backward interpolation, Cubic spline interpolation.
(vii) Integration: Gauss quadrature rule, Integration by Monte Carlo method, Double integration.
(viii) Solution of ODE: Eulers and Modified Eulers, Runge-Kuta, Predictor and Corrector method: Milne method.
(ix) Solution of PDE by Finite difference method.
(x) Eigen value of a matrix: Power method, Jacobi method.

On Statistical Problems:

(i) On bivariate distribution: Correlation coefficient, Regression lines, Curve fitting.
(ii) Multiple regression.
(iii) Simple hypothesis testing.

Semester-IV

MA2201 Topology 25
Gr. A

Elements of topological spaces, continuity, convergence. Homomorphism, compactness, connectedness, separation axioms, first and second countability, separability. Subspaces, product topology, product spaces. Quotient spaces, Tychonoff's theorem, Urysohn's lemma, Urysohn's metrization theorem. Homotopy and fundamental group.

MA2201 Data Structure and Design and Analysis of Algorithms 25
Gr. B

Data structure: Asymptotic notations- o, O, θ, Θ, ω, Ω and their properties. Arrays, stacks, queues. Linked list. Trees. Binary trees. Evaluation of expression. Addition of polynomial using linked list and other examples. *M*-way search tree. B-tree (concept only).
Analysis of algorithms.

Searching: Linear and binary and their analysis.

Sorting: Quick, heap and merge sorts and their analysis.

Algorithms design techniques: Divide-and-conquer method. Greedy method. Dynamics programming technique. Branch-and-bound method. Examples.

Representation of graph in a computer. Graph searching. Binary tree traversals. Spanning tree. Shortest path problem. NP-Completeness.

MA2202 Differential Geometry 25
Gr. A

Space Curves-their curvature and torsion, Serret Frehat Formula, Fundamental theorem of space curves, Curves on surfaces, First and second fundamental form, Gaussian curvatures, Principal directions and principal curvatures, Geodesics, Fundamental equations of surface theory.

MA2202 Magneto Hydro-Dynamics 25
Gr. B

Maxwell's electromagnetic field equations when medium in motion. Lorentz's force. The equations of motion of a conducting fluid. Basic equations. Simplification of the electromagnetic field equation. Magnetic Reynolds number. Alfven theorem. Magnetic body force. Ferraro's law of isorotation. Laminar Flow of a viscous conducting liquid between parallel walls in transverse magnetic fields. M.H.D. Flow Past a porous flat plate. MHD Couelte Flow under different boundary conditions, Magneto hydro dynamics waves.

MA2203 Fuzzy Sets and their Applications 25
Gr. A

Definition of Fuzzy sets. Alpha-set. Normality Extension Principle. Basic Operations like inclusion. Completion, Union and intersection, Difference.

Fuzzy numbers. Addition, Subtraction, Multiplication and Division, Triangular and trapezoid fuzzy numbers.

Linear Programming Problems with fuzzy resources :

(i) Vendegay's approach

(ii) Werner's approach

L.P.P. with fuzzy resources and objective : Zimmermann's approach.

L.P.P. with fuzzy parameters in the objective function. Definition of Fuzzy multiobjective linear programming problems. A brief survey of the methodology of solving fuzzy M.O.L.P. and fuzzy goal programming.

Either soft computing techniques or gas dynamics is to be opted by the students.

MA2203 Soft Computing 25
Gr. B

Introduction of soft computing, fuzzy logic, Genetic Algorithm, Neural networks, Application of fuzzy logic concepts in scientific problems, Solution of optimization problems using Genetic Algorithm. Neural Network approaches in scientific analysis, design, and diagnostic problems.

MA2203 Gas Dynamics 25
Gr. B

Basic concept of thermodynamics. First Law of thermodynamics. Internal energy. Specific heats of gas. Entropy. Second Law of thermodynamics. Maxwell's thermodynamic relations. Wave motion. Wave motion in two and three dimensions, Progressive and stationary waves, Speed of sound in gas. Equations of motion of a gas. Subsonic, Sonic, Supersonic flow, Isentropic gas flow. Shock waves, Formation of shock waves. Elementary analysis of normal and oblique shock waves. The method of characteristics for two dimensional, Homentropic irrotational gas flow.

MA2204 Special Paper-OM 50
Dynamical Oceanology-II

The vorticity equation, Potential vorticity, The thermal wind, The Taylor-Proudman theorem, inertial waves, Geostropic motion, Consequences of the Geostropic and Hydrostatic. Rossby number, Exman number, The shallow-water equations, Potential vorticity conservation. Plane wave in a layer of constant depth. Poincare-Kelvin waves. The Rossby waves, Dynamics diagonosis of the Rossby waves.

Homogeneous Models of the wind-driven steady oceanic circulation : Derivation of the wind-driven steady oceanic circulation, Derivation of the Vorticity equation in terms of geostrophic stream function and the relevant boundary conditions, The Sverdrup relation, Meridional boundary layers, Bottom friction layer, Inertial boundary layer theory, Inertial currents in the presence of friction, dissipation integrals for steady circulation, Ekman upwelling circulation.

Quasigeostrophic motion of a stratified fluid on a sphere : The equations of motion in a spherical coordinates, Scaling, geostrophic approximation for synoptic scales, The concept of static stability, quasigeostrophic potential vorticity equation for oceanic synoptic scales and relevant boundary conditions, Rossby Wave normal modes, The vertical structure equation, Topographic waves in a stratified ocean, Geostrophic approximation for large scale, The thermocline problems, Barotropic and Baroclinic Rossby waves.

Internal waves in a rotating nondissipative stratified fluid, Inertial waves.

MA2205 Special Paper-OM 25
Dynamical Meteorology-II

Fronts, Cyclones and Anticyclones : Surface of discontinuity, Pressure distribution near Fronts, Temperature and wind distribution at Fronts, Classification of Fronts, The geostrophic Fronts, The motion of Fronts, Tropical Cyclones, CISK, The wave theory of cyclones, Storm Surges.

Atmosphere Turbulence : Prandtls theory of momentum transfer, The vertical variation of the wind in and above the surface layer, Vertical Mixing, Air Masses.

MA2204 Special Paper-OR
Non-Linear Optimization 50

Optimization : The nature of optimization and scope of the theory. The optimality criterion of Linear programming. An application of Farka's Theorem. Existence Theorem for Linear systems. Theorems of the alternatives.

Optimality in the absence of differentiability, Slater's constraint qualification, Karlin's constraint qualification, Kuhn-Tucker's saddle point necessary optimality Theorem.

Optimality criterion with differentiability and Convexity, Kuhn-Tucker's Sufficient optimality theorem, Duality in non-linear programming, Weak duality theorem, Wolfe's duality theorem, Duality for quadratic programming.

Large scale linear programming : Decomposition principle of Dantzig and Wolfe, Composite simplex algorithm.

Quadratic Programming: Wolfe's modified simplex method, Beale's method. Convex Programming.

Stochastic Programming : Chance Constraint programming technique.

Geometric Programming : Geometric programming (both unconstrained and constrained).

Games: Preliminary concept of Continuous Game, Bimatrix Games, Nash Equilibrium, Solution of bimatrix games through Quadratic Programming (Relation with Nonlinear Programming).

MA2205 Special Paper-OR 25
Operational Research Modelling-II

Optimal Control: Performance indices, Methods of calculus of variations, Transversally Conditions, Simple optimal problems of mechanics, Pontryagin's principle (with proof assuming smooth condition), Linear regulator, Application of dynamic programming in proving Pontryagin's principle, Bang –bang Controls.

Sequencing: Problems with n jobs two machines, n-jobs three machines and n-jobs, m-machines.

Reliability: Concept, Reliability Definition , System Reliability, System Failure rate, Reliability of the Systems connected in Series or / and parallel.

Information Theory: Introduction, Communication Processes— memory less channel, the channel matrix, Probability relation in a channel, noiseless channel.

A Measure of information- Properties of Entropy function, Measure of Other information quantities — marginal and joint entropies, conditional entropies, expected mutual information, Axiom for an Entropy function, properties of Entropy function.

Channel capacity, efficiency and redundancy.

Encoding — Objectives of Encoding.

Shannon — Fano Encoding Procedure, Necessary and sufficient Condition for Noiseless Encoding.

MA2206 Grand Viva 25

The viva is to be taken from the entire syllabus of all semesters.

MA2211 Lab. 4: (Data Base Management System and Software Development) 25

Problem: 20 marks; Lab. note book and viva: 5.
Data base management system. Need and use. Commands of DBMS/RDBMS.
The following problems are to be solved using C, C++ or any package of RBDMS.

(i) Inventory management,
(ii) Preparation of merit list for admission to M.Sc. courses,
(iii) Library management,
(iv) Publication of result,
(v) Evaluation of journal grade,
(vi) Data base for Alumni,
(vii) Preparation of pay statement of employees,
(viii) A class of matrices using C++.

MA2212 Lab. 5 (Lab. on Special Paper) 25

Lab. on Special Paper – OM (Problems on Meteorology)

1. Surface temperature, pressure, humidity, Wind speed and direction measurements.
2. Rainfall and rain measurements.
3. TD charts-analysis.
4. T- Φ diagram :
   i) Geopotential height by isotherm / adiabatic method.
   ii) To find dry bulb and wet bulb temperature, potential, virtual, equivalent potential, dew point temperatures and mixing ratio.
5. Numerical method and computer techniques related to Meterological problems, Handling and analysis of Meteorological data.
6. Field worked (5-marks) (compulsory)**:** Students should go to one of the University/Institute/Organization laboratory (preferably in the laboratory of I.M.D, I.I.Sc, I.I.M, N.P.L, I.I.T. etc.) to understand experimental set-ups in advance meteorology (such as Annular experiment for existence of general circulation and Rossby wave, experiment for demonstrating Helmholtz instability, Aerosol measurements, Facsimile recorder for receiving weather charts etc.)

Lab. on Special Paper – OR (Problems on Advanced Optimization and Operations Research)

The following problems are to be solved by using C/C++ language

1. Problems on LPP by simplex method,
2. Problems on LPP by revised simplex method,
3. Problems on stochastic programming,
4. Problems on geometric programming,
5. Problems on bi-matrix games,
6. Problems on queuing theory,
7. Problems on QPP by Wolfe's modified method and Beale's method,
8. Problems on IPP by Gomory's cutting plane method,
9. Problems on Networking (PERT and CPM),
11. Problems on inventory,
12. Problems on Monte Carlo simulation techniques,
13. Problems on dynamic programming.