FOREST RESEARCH INSTITUTE DEEMED UNIVERSITY

SYLLABUS OF PH.D. ENTRANCE TEST

The question paper will have following sections and their proportional weightage may be as follows :

Section-A

1. Research Methodology: 100 questions

(The questions will be based on Maths, Reasoning, Statistics and English)

Section-B

1. General Forestry : 50 questions
2. Subject/discipline specific: 50 questions

(as per the discipline applied for)

Sl. No.	Discipline applied for	Subject to be attempted compulsorily as per discipline applied for
1.	Silviculture/ Forest Seed Technology/ Forest Management/ Non Wood Forest Products / Forestry Extension.	Forestry
2.	Forest Genetics/Forest Botany/ Forest Pathology/ Forest Entomology/ Forest Ecology & Environment/ Forest Biotechnology/ Environment Management/ Wildlife Science/Soil Science	Life Sciences **or** Environmental Sciences
3.	Wood Science & Technology/ Forest Geo-informatics/ Forest Hydrology/Climate Change & Forest Influence	Forestry **or** Physics **or** Wood Science & Technology
4.	Chemistry of Forest Products/ Pulp & Paper Technology.	Chemistry **or** Pulp & Paper Technology
5.	Forest Bio-informatics	Life Science **or** Mathematics

(i) **The candidates securing minimum 30% and above marks in Section-B will only be considered for qualifying Entrance Test**.

(ii) Overall the minimum qualifying marks in entrance examination for general candidate is 50% and for the SC/ST/OBC (non-creamy layer)/differently-abled and other categories of candidates as per the decision of the Commission from time to time is 45%.

LIFE SCIENCES

1. MOLECULES AND THEIR INTERACTION RELAVENT TO BIOLOGY

A. Structure of atoms, molecules and chemical bonds.
B. Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).
C. Stablizing interactions (Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).
D. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).
E. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.
F. Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes.
G. Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds).
H. Conformation of nucleic acids (A-, B-, Z-,DNA), t-RNA, micro-RNA).
I. Stability of protein and nucleic acid structures.
J. Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins.

2. CELLULAR ORGANIZATION

A. Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
B. **Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.
C. **Organization of genes and chromosomes:** Operon, interrupted genes, gene families, structure of chromatin and chromosomes, unique and repetitive DNA, heterochromatin, euchromatin, transposons.
D. Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle.
E. Microbial Physiology: Growth, yield and characteristics, strategies of cell division, stress response.

3. FUNDAMENTAL PROCESSES

A. DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms.
B. RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.
C. Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, post- translational modification of proteins.

D. Control of gene expression at transcription and translation level: Regulation of phages, viruses, prokaryotic and eukaryotic gene expression, role of chromatin in regulating gene expression and gene silencing.

4. CELL COMMUNICATION AND CELL SIGNALING

A. Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.
B. Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.
C. Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

5. DEVELOPMENTAL BIOLOGY

A. Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.
B. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.
C. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum.*
E. Programmed cell death, aging and senescence.

6. SYSTEM PHYSIOLOGY – PLANT

A. Photosynthesis: Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C_3, C_4 and CAM pathways.
B. **Respiration and photorespiration:** Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.
C. Nitrogen metabolism: Nitrate and ammonium assimilation; amino acid biosynthesis.
D. Plant hormones: Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.
E. Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.
F. Solute transport and photoassimilate translocation: Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilates.
G. Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

H. Stress physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress

7. INHERITANCE BIOLOGY

A. Mendelian principles: Dominance, segregation, independent assortment, deviation from Mendelian inheritance.
B. Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests.
C. Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.
D. Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.
E. Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance.
F. Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.
G. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. **H. Quantitative genetics:** Polygenic inheritance, heritability and its measurements, QTL mapping.
I. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.
J. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
K. Recombination: Homologous and non-homologous recombination, including transposition, site-specific recombination.

9. DIVERSITY OF LIFE FORMS

A. **Principles and methods of taxonomy:**Concepts of species and hierarchical taxa, biological nomenclature, classical and quantititative methods of taxonomy of plants, animals and microorganisms.
B. Levels of structural organization: Unicellular, colonial and multicellular forms; levels of organization of tissues, organs and systems; comparative anatomy.
C. Outline classification of plants, animals and microorganisms: Important criteria used for classification in each taxon; classification of plants, animals and microorganisms; evolutionary relationships among taxa.

10. ECOLOGICAL PRINCIPLES

A. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.
B. Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
C. Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.
D. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
E. Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
F. Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

G. Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

H. Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

I. Applied ecology: Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

J. Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

11. EVOLUTION AND BEHAVIOUR

A. Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; the evolutionary synthesis.

B. Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

C. Paleontology and evolutionary history: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants and animals; stages in primate evolution including Homo. **D. Molecular Evolution:** Concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

E. The Mechanisms: Population genetics – populations, gene pool, gene frequency; Hardy-Weinberg law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; adaptive radiation and modifications; isolating mechanisms; speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.

12. APPLIED BIOLOGY:

A. Microbial fermentation and production of small and macro molecules.

B. Application of immunological principles (vaccines, diagnostics). tissue and cell culture methods for plants and animals.

C. Transgenic animals and plants, molecular approaches to diagnosis and strain identification.

D. Genomics and its application to health and agriculture, including gene therapy.

E. Bioresource and uses of biodiversity.

F. Breeding in plants and animals, including marker – assisted selection.

G. Bioremediation and phytoremediation.

H. Biosensors.

13. METHODS IN BIOLOGY

A. Molecular biology and recombinant DNA methods: Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems; expression of recombinant proteins using bacterial, animal and plant vectors; isolation of specific nucleic acid sequences; generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; in vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms; protein sequencing methods, detection of post-translation modification of proteins; DNA sequencing methods, strategies for genome sequencing; methods for analysis of gene

expression at RNA and protein level, large scale expression analysis, such as micro array based techniques; isolation, separation and analysis of carbohydrate and lipid molecules; RFLP, RAPD and AFLP techniques

B. Histochemical and immunotechniques: Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, floweytometry and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH.

C. Biophysical methods: Analysis of biomolecules using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction and NMR; analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.

D. Methods in field biology: Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization-ground and remote sensing methods.

E. Computational methods: Nucleic acid and protein sequence databases; data mining methods for sequence analysis, web-based tools for sequence searches, motif analysis and presentation.

PHYSICS

I. **Mathematical Methods of Physics**
Dimensional analysis; Vector algebra and vector calculus; Linear algebra, matrices, Cayley Hamilton theorem, eigenvalue problems; Linear differential equations; Special functions (Hermite, Bessel, Laguerre and Legendre); Fourier series, Fourier and Laplace transforms; Elements of complex analysis: Laurent series-poles, residues and evaluation of integrals; Elementary ideas about tensors; Introductory group theory, SU(2), O(3); Elements of computational techniques: roots of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, solution of first order differential equations using Runge-Kutta method; Finite difference methods; Elementary probability theory, random variables, binomial, Poisson and normal distributions.

II. **Classical Mechanics**
Newton's laws; Phase space dynamics, stability analysis; Central-force motion; Two-body collisions, scattering in laboratory and centre-of-mass frames; Rigid body dynamics, moment of inertia tensor, non-inertial frames and pseudoforces; Variational principle, Lagrangian and Hamiltonian formalisms and equations of motion; Poisson brackets and canonical transformations; Symmetry, invariance and conservation laws, cyclic coordinates; Periodic motion, small oscillations and normal modes; Special theory of relativity, Lorentz transformations, relativistic kinematics and mass–energy equivalence.

III. **Electromagnetic Theory**
Electrostatics: Gauss' Law and its applications; Laplace and Poisson equations, boundary value problems; Magnetostatics: Biot-Savart law, Ampere's theorem, electromagnetic induction; Maxwell's equations in free space and linear isotropic media; boundary conditions on fields at interfaces; Scalar and vector potentials; Gauge invariance; Electromagnetic waves in free space, dielectrics, and conductors; Reflection and refraction, polarization, Fresnel's Law, interference, coherence, and diffraction; Dispersion relations in plasma; Lorentz invariance of Maxwell's equations; Transmission lines and wave guides; Dynamics of charged particles in static and uniform electromagnetic fields; Radiation from moving charges, dipoles and retarded potentials.

IV. **Quantum Mechanics**
Wave-particle duality; Wave functions in coordinate and momentum representations; Commutators and Heisenberg's uncertainty principle; Matrix representation; Dirac's bra and ket notation; Schroedinger equation (time-dependent and time-independent); Eigenvalue problems such as particle-in-a-box, harmonic oscillator, etc.; Tunneling through a barrier; Motion in a central potential; Orbital angular momentum, Angular momentum algebra, spin; Addition of angular momenta; Hydrogen atom, spin-orbit coupling, fine structure; Time-independent perturbation theory and applications; Variational method; WKB approximation; Time dependent perturbation theory and Fermi's Golden Rule; Selection rules; Semi-classical theory of radiation; Elementary theory of scattering, phase shifts, partial waves, Born approximation; Identical particles, Pauli's exclusion principle, spin-statistics connection; Relativistic quantum mechanics: Klein Gordon and Dirac equations.

V. **Thermodynamic and Statistical Physics**
Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, micro- and macrostates; Microcanonical,

canonical and grand-canonical ensembles and partition functions; Free Energy and connection with thermodynamic quantities; First- and second-order phase transitions; Classical and quantum statistics, ideal Fermi and Bose gases; Principle of detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation; Random walk and Brownian motion; Introduction to nonequilibrium processes; Diffusion equation.

VI. **Condensed Matter Physics**

Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding of solids; Elastic properties, phonons, lattice specific heat; Free electron theory and electronic specific heat; Response and relaxation phenomena; Drude model of electrical and thermal conductivity; Hall effect and thermoelectric power; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of metals, insulators and semiconductors; Superconductivity, type – I and type - II superconductors, Josephson junctions; Defects and dislocations; Ordered phases of matter, translational and orientational order, kinds of liquid crystalline order; Conducting polymers; Quasicrystals.

CHEMISTRY

Physical Chemistry:

1. Basic principles and applications of quantum mechanics – hydrogen atom, angular momentum.
2. Variational and perturbational methods.
3. Basics of atomic structure, electronic configuration, shapes of orbitals, hydrogen atom spectra.
4. Theoretical treatment of atomic structures and chemical bonding.
5. Chemical applications of group theory.
6. Basic principles and application of spectroscopy – rotational, vibrational, electronic, Raman, ESR, NMR.
7. Chemical thermodynamics.
8. Phase equilibria.
9. Statistical thermodynamics.
10. Chemical equilibria.
11. Electrochemistry – Nernst equation, electrode kinetics, electrical double layer, Debye-Hückel theory.
12. Chemical kinetics – empirical rate laws, Arrhenius equation, theories of reaction rates, determination of reaction mechanisms, experimental techniques for fast reactions.
13. Concepts of catalysis.
14. Polymer chemistry. Molecular weights and their determinations. Kinetics of chain polymerization.
15. Solids - structural classification of binary and ternary compounds, diffraction techniques, bonding, thermal, electrical and magnetic properties
16. Collids and surface phenomena.
17. Data analysis.

Inorganic Chemistry

1. Chemical periodicity
2. Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules.
3. Concepts of acids and bases.
4. Chemistry of the main group elements and their compounds. Allotropy, synthesis, bonding and structure.
5. Chemistry of transition elements and coordination compounds – bonding theories, spectral and magnetic properties, reaction mechanisms.
6. Inner transition elements – spectral and magnetic properties, analytical applications.

7. Organometallic compounds - synthesis, bonding and structure, and reactivity. Organometallics in homogenous catalysis.
8. Cages and metal clusters.
9. Analytical chemistry- separation techniques. Spectroscopic electro- and thermoanalytical methods.
10. Bioinorganic chemistry – photosystems, porphyrines, metalloenzymes, oxygen transport, electron- transfer reactions, nitrogen fixation.
11. Physical characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-, NQR, MS, electron spectroscopy and microscopic techniques.
12. Nuclear chemistry – nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis.

Organic Chemistry

1. IUPAC nomenclature of organic compounds.
2. Principles of stereochemistry, conformational analysis, isomerism and chirality.
3. Reactive intermediates and organic reaction mechanisms.
4. Concepts of aromaticity.
5. Pericyclic reactions.
6. Named reactions.
7. Transformations and rearrangements.
8. Principles and applications of organic photochemistry. Free radical reactions.
9. Reactions involving nucleophotic carbon intermediates.
10. Oxidation and reduction of functional groups.
11. Common reagents (organic, inorganic and organometallic) in organic synthesis.
12. Chemistry of natural products such as steroids, alkaloids, terpenes, peptides, carbohydrates, nucleic acids and lipids.
13. Selective organic transformations – chemoselectivity, regioselectivity, stereoselectivity, enantioselectivity. Protecting groups.
14. Chemistry of aromatic and aliphatic heterocyclic compounds.
15. Physical characterisation of organic compounds by IR, UV-, MS, and NMR.

Interdisciplinary topics

1. Chemistry in nanoscience and technology.

2. Catalysis and green chemistry.

3. Medicinal chemistry.

4. Supramolecular chemistry.

5. Environmental chemistry.

MATHEMATICS

PART – I

Elementary set theory, finite, countable and uncountable sets, Real number system, supremum, infimum, Sequences and series, convergence, limsup, liminf, Bolzano Weierstrass theorem, Heine Borel theorem, Continuity, uniform continuity, differentiability, mean value theorem, Sequences and series of functions, uniform convergence, Riemann sums and Riemann integral, Improper Integrals, Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue, measure, Lebesgue integral, Functions of several variables, directional derivative, partial derivative, derivative as a, linear transformation, Metric spaces, compactness, connectedness. Normed Linear Spaces. Spaces of, Continuous functions as examples.

Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations, Algebra of matrices, rank and determinant of matrices, linear equations, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms, Inner product spaces, orthonormal basis, Quadratic forms, reduction and classification of quadratic forms.

PART – 2

Algebra of complex numbers, the complex plane, polynomials, Power series, transcendental functions such as exponential, trigonometric and hyperbolic, functions, Analytic functions, Cauchy-Riemann equations, Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem, Taylor series, Laurent series, calculus of residues.

Permutations, combinations, pigeon-hole principle, inclusion-exclusion, principle, derangements, Fundamental theorem of arithmetic, divisibility in Z, congruences, Chinese Remainder, Theorem, Euler's Ø- function, primitive roots, Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley's theorem, class equations, Sylow theorems, Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain, Polynomial rings and irreducibility criteria, Fields, finite fields, field extensions.

PART – 3

Existence and Uniqueness of solutions of initial value problems for first order ordinary, differential equations, singular solutions of first order ODEs, system of first order ODEs, General theory of homogenous and non-homogeneous linear ODEs, variation of, parameters, Sturm-Liouville boundary value problem, Green's function.

Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs, Classification of second order PDEs, General solution of higher order PDEs with, constant coefficients, Method of separation of variables for Laplace.

Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson, method, Rate of convergence, Solution of systems of linear algebraic equations using, Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Characteristic numbers and eigenfunctions, resolvent kernel.

Generalized coordinates, Lagrange's equations, Hamilton's canonical equations, Hamilton's principle and principle of least action, Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations.

PART – 4

Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables, marginal and conditional distributions. Characteristic functions. Probability inequalities (Tchebyshef, Markov, Jensen). Modes of convergence, weak and strong laws of large numbers, Central Limit theorems (i.i.d. case).

Standard discrete and continuous univariate distributions. Sampling distributions. Standard errors and asymptotic distributions, distribution of order statistics and range. Methods of estimation. Properties of estimators. Confidence intervals. Tests of hypotheses: most powerful and uniformly most powerful tests, Likelihood ratio tests. Analysis of discrete data and chi-square test of goodness of fit. Large sample tests. Simple nonparametric tests for one and two sample problems, rank correlation and test for independence. Elementary Bayesian inference. Best linear unbiased estimators, tests for linear hypotheses and confidence intervals. Analysis of variance and covariance. Fixed, random and mixed effects models. Simple and multiple linear regression. Elementary regression diagnostics. Logistic regression. Multivariate normal distribution, Wishart distribution and their properties. Distribution of quadratic forms. Inference for parameters, partial and multiple correlation coefficients and related tests. Data reduction techniques: Principle component analysis, Discriminant analysis, Cluster analysis, Canonical correlation. Simple random sampling, stratified sampling and systematic sampling. Probability proportional to size sampling. Ratio and regression methods. Completely randomized, randomized blocks and Latin-square designs. Connected, complete and orthogonal block designs, BIBD. 2 K factorial experiments: confounding and construction.

Linear programming problem. Simplex methods, duality. Elementary queuing and inventory models.

PART – 5

Programming and programming language concepts, Operating systems, process management, memory management, UNIX, Shell programming, system administration, software engineering, System investigations, Programming in PASCAL – control structure, array and records, subprograms, pointers, files and sets

C Programming, Data types, operator and expressions, Decision Structure, Control structure, Union and Bit fields

System analysis, feasibility study, System design and control, Quality assurance, MIS, building a management information system, Introductory Multimedia, Microprocessor and assembly language programming, data processing through COBOL.
Database management systems, concepts, models and implementation, file organization, conventional DBMS. RDBMS and DDBMS. Relational model, SQL, Distributed databases, Object Oriented DBMS Relational Model, Client / Server Database.

FORESTRY

1. Silviculture:

General Silvicultural Principles : ecological and physiological factors influencing vegetation, natural and artificial regeneration of forests; methods of propagation, grafting techniques; site factors; nursery and planting techniques-nursery beds, polybags and maintenance, water budgeting, grading and hardening of seedlings; special approaches; establishment and tending. Clear felling, uniform shelter wood selection, coppice and conversion systems. Management of silviculture systems of temperate, subtropical, humid tropical, dry tropical and coastal tropical forests with special reference to plantation silviculture, choice of species, Traditional and recent advances in tropical silvicultural research and practices. Silviculture of some of the economically important species in India

2. Agroforestry, Social Forestry, Joint Forest Management:

Agroforestry - scope and necessity; role in the life of people and domestic animals and in integrated land use, planning especially related to (i) soil and water conservation; (ii) water recharge; (iii) nutrient availability to crops; (iv) nature and eco-system preservation including ecological blances through pest-predator relationships and (v) providing opportunities for enhancing bio-diversity, medicinal and other flora and fauna. Agro forestry systems under different agro-ecological zones; selection of species and role of multipurpose trees and NTFPs, techniques, food, fodder and fuel security. Research and Extension needs. Social/Urban Forestry : objectives, scope and necessity; peoples participation. JFM - principles, objectives, methodology, scope, benefits and role of NGOs.

3. Forest Soils, Soil Conservation and Watershed management:

Forests Soils, classification, factors affecting soil formation; physical, chemical and biological properties.

Soil conservation - definition, causes for erosion; types - wind and water erosion; conservation and management of eroded soils/areas, wind breaks, shelter belts; sand dunes; reclamation of saline and alkaline soils, water logged and other waste lands. Role of forests in conserving soils. Maintenance and build up of soil organic matter, provision of loppings for green leaf manuring; forest leaf litter and composting; Role of microorganisms in ameliorating soils; N and C cycles, VAM.

Watershed Management - concepts of watershed; role of mini-forests and forest trees in overall resource management, forest hydrology, watershed development in respect of torrent control, river channel stabilization, avalanche and landslide controls, rehabilitation of degraded areas; hilly and mountain areas; watershed management and environmental functions of forests; water-harvesting and conservation; ground water recharge and watershed management; role of integrating forest trees, horticultural crops, field crops, grass and fodders.

4. Environmental Conservation and Biodiversity :

Environment; components and importance, principles of conservation, impact of deforestation; forest fires and various human activities like mining, construction and developmental projects, population growth on environment. Pollution - types, global warming, green house effects, ozone layer depletion, acid rain, impact and control measures, environmental monitoring; concept of sustainable development. Role of trees and forests in environmental conservation; control and prevention of air, water and noise pollution. Environmental policy and legislation in India. Environmental Impact Assessment. Economics assessment of watershed development vis-a-vis ecological and environmental protection.

5. Tree Improvement and Seed Technology :

General concept of tree improvement, methods and techniques, variation and its use, provenance, seed source, exotics; quantitative aspects of forest tree improvement, seed production and seed orchards, progeny tests, use of tree improvement in natural forest and stand improvement, genetic testing programming, selection and breeding for resistance to diseases, insects, and adverse environment; the genetic base, forest genetic resources and gene conservation in situ and ex-situ. Cost benefit ratio, economic evaluation.

6. Forest Mensuration and Remote Sensing :

Methods of measuring - diameter, girth, height and volume of trees; form-factor; volume estimation of stand, current anuual increment; mean annual increment. Sampling methods and sample plots. Yield calculation; yield and stand tables, forest cover monitoring through remote sensing; Geographic Information Systems for management and modelling.

7. Forest Ecology and Ethnobotany :

Forest ecology - Biotic and aboitic components, forest eco-systems; forest community concepts; vegetation concepts, ecological succession and climax, primary productivity, nutrient cycling and water relations; physiology in stress environments (drought, water logging salinity and alkalinity). Forest types in India, identification of species, composition and associations; dendrology, taxonomic classification, principles and establishment of herbaria and arboreta. Conservation of forest ecosystems. Clonal parks, Role of Ethnobotany in Indian Systems of Medicine; Ayurveda and Unani - Introduction, nomenclature, habitat,

distribution and botanical features of medicinal and aromatic plants. Factors affecting action and toxicity of drug plants and their chemical constituents.

8. Forest Resources and Utilization :

Environmentally sound forest harvesting practices; logging and extraction techniques and principles, transportation system, storage and sale; Non-Timber Forest Products (NTFPs) definition and scope; gums, resins, oleoresins, fibres, oil seeds nuts, rubber, canes, bamboos, medicinal plants, charcoal, lac and shellac, Katha and Bidi leaves, collection; processing and disposal. Need and importance of wood seasoning and preservation; general principles of seasoning, air and kiln seasoning, solar dehumidification, steam heated and electrical kilns. Composite wood; adhesives-manufacture, properties, uses, plywood manufacture-properties, uses, fibre boards-manufacture properties, uses; particle boards manufacture; properties uses. Present status of composite wood industry in India in future expansion plans. Pulp-paper and rayon; present position of supply of raw material to industry, wood substitution, utilization of plantation wood; problems and possibilities. Anatomical structure of wood, defects and abnormalities of wood, timber identification - general principles.

9. Forest Protection & Wildlife Biology :

Injuries to forest - abiotic and biotic, destructive agencies, insect-pests and disease, effects of air pollution on forests and forest die back. Susceptibility of forests to damage, nature of damage, cause, prevention, protective measures and benefits due to chemical and biological control. General forest protection against fire, equipment and methods, controlled use of fire, economic and environmental costs; timber salvage operations after natural disasters. Role of afforestation and forest regeneration in absorption of CO2. Rotational and controlled grazing, different methods of control against grazing and browsing animals; effect of wild animals on forest regeneration, human impacts; encroachement, poaching, grazing, live fencing, theft, shifting cultiation and control.

ENVIRONMENT SCIENCE

Unit-I: Environment Physics and Biogeochemistry

Structure of the atmosphere, radiation budgets, general circulation in the atmosphere, prevailing and adiabatic lapse rates, air masses and fronts, vertical profiles of major and trace gases; cloud formation and precipitation, cloud classification, condensation nuclei, global patterns of pressure and winds, monsoon systems. Chemical composition and processes in the atmosphere, atmospheric photochemistry, reactions of nitrogen, oxygen, ozone, chlorides.

Transport and deposition processes of dust and aerosols in the atmosphere.

Chemistry of hydrosphere; properties of water, surface and ground water, physical chemistry of sea water, characteristics of natural water, complexation in natural water and waste water, aquatic chemical reactions.

Landform and their development; structure and tectonics, weathering, erosion, classification, structural classification of minerals and their properties; major rock forming and ore minerals, geochemical classification and distribution of elements in the earth, properties of soil parent materials and their relation to soil and vegetation.

Definition of soil, soil types, factors of soil formation, weathering of rocks & minerals and processes of soil formation, soil profile.

Soil physico-chemical properties; soil water, types of soil water, its retention, movement, availability and measurement of soil water, soil organic matter and its role in soil fertility.

Causes, kinds, extents of soil degradation & pollution and measures for their prevention & amelioration.

Plant nutrition; essential nutrients and their forms in the soil and their role in plant growth, factors and forms of erosion.

Unit-II: Natural Resource Conservation and Management

Introduction : Current issues, challenges and innovative solution for society and natural resources, Public policy. Law and public involvement: the Endangered species Act, the clean water Act, Renewable & Non renewable resources.

Forest resources ; distribution of forests, wood production, carbon sequestration, non-wood forest produce, cost associated with forest exploitation, cost of felling/removal & transportation of forest produce, energy cost for forest exploitation, environmental cost, loss of habitat, deforestation impact reforestation and processing cost, sustainable management

Mineral resources, distribution and management, economics of mineral resources, cost associated with mineral exploitation, economic cost, energy cost, environmental cost, steps in mineral exploitation, recycling as an alternative.

Soil structure and use, soil formation, decomposition of parent rock, formation of humus and organic matter, soil properties, soil structure, soil texture, soil profile, soil erosion, water holding capacity, biological activity in soil, soil conservation practice, land capability classes, contour

forming strip forming, terracing,, Water resources, water management wind erosion, use of wind breaks.

Wildlife resources, restoration of wildlife, habitat management.

Unit-III: Foundation Course in Ecology and Environment Management

Definition of ecology, **natural ecosystems**, species and individuals, population parameters and population growth, structure and composition, life history strategies, **alpha, beta, gamma diversity** and dominance, concept of carrying capacity, population fluctuation and regulation.

Autecology and population dynamics, ecological life cycle, ecotypic differentiation, population characteristics and dynamics-k selection, species interaction and intra and inter specific competition, evolutionary consequences of competition, allelopathy and **keystone species.**

Synecology and **community dynamics, methods and purpose of studying plant communities**, qualitative characteristics, life forms,**quantitaive characteristics, species-area curve, ecological sampling of an area (line transect, Centre point method. and quadrat (method), quantitative structure of plant, communities, ecotone**, habitat and niche, dominance and diversity, community dynamics, and spatial pattern community size, ecological succession and climax, successional models.

Structure and composition of community, **recruitment** and mortality community coefficients, cluster analysis, association analysis, gradient analysis, vegetation mapping.

Ecosystem components and structure, abiotic and biotic factors, trophic relations, influences of climatic factors on major ecosystems of the world, food chains and edaphic factors, functional aspects of ecosystem: biomass and productivity-primary production, gross and net production, estimation methods,

Unit-IV: Disaster Management

Natural disasters, nature, causes and effects, cyclone, tornadoes, floods, earthquakes, avalanches, land slides, drought, diseases, and fire.

Forecasting and warning systems of disasters, measurements of responses of disasters, community reaction to disaster, coping mechanism, classes of victims.

Disaster management, pre-disaster phase, actual disaster phase, post-disaster phase, disaster assistance, technological assistance, relief camps, organization, camp layout, fire fighting camping and tent pitching, rope, knots and their use, rescue, emergency rescue.

Disaster education

Alternatives and new directions, conceptualizing disaster recovery, mitigation and preparedness, programme planning and management.
Case studies of disasters.

Unit-V: Global Climatic Changes

Climate Change**:** Earth's Climate System, Past, Present and Future Climate. The greenhouse effect and major Greenhouse gases. Future Climate Scenarios and its impact on tropical and temperate regions. Adaptability of ecosystem to climate change. India specific impact of climate change.

Climate Change Mitigation**:** Way and means, the concept of Carbon Sequestration..

Global Carbon Cycle: Stocks and Fluxes of Carbon in terrestrial and marine ecosystems and anthropogenic impact.

Policy Perspective: UNFCC, Role and Function of IPCC, Kyoto Protocol and its implication on Developed and developing countries, operationalization of Kyoto Protocol. The Clean Development Mechanism (CDM) and its operationalization, modalities and procedures for CDM Project, National Communication to the UNFCCC (NATCOM).

The Energy Perspective: National and International for Energy use and its implication on Climate Change.

The Forestry Perspective: Forest: Source or Sink of Carbon, Measuring of Carbon Dioxide. The Climate Mitigation potential of Forest and its evaluation, Land use, Land use Change and Forestry (LULUCF), Evolution of LULUCF in CDM. How to develop Carbon Sequestration Projects their Modalities and Procedures.

Unit-VI: Environmental Pollution Management

Air pollution control equipments viz. settling chambers, inertial separators, cyclones, multiple cyclones, baghouse filters, scrubbers or wet collectors, electrostatic precipitators, advantages and disadvantages of control equipments.

Air pollution abatement technologies including vehicular emissions.

Water Pollution, causes, pollution categorization, sewage, infectious agents, nutrients, chemicals, organic and inorganic, sediments, radioactive materials, thermal, reclamation of polluted water, effluent treatment, treatment of sewage water and ground water resource

Eutrophication, causes, consequences and control, biomanipulation and ecorestoration of lakes, environmental health and sanitation

Basic properties of sound waves-plane and spherical wave, sound pressure and intensity levels, decibel, effect of meteorological parameters on sound propagation**.** measurement and analysis of sound. A weighted sound level; equivalent sound pressure level (Leq).

Noise pollution level (NPL), sound exposure level (SEL), traffic noise index (TNI), day-night level, noise criteria curves; noise sources; machinery noise, pumps; compressors, building and construction equipment, domestic appliances, traffic- vehicular, train, aircraft, diesel generator sets.

Prediction of traffic noise-nomograph method. Noise control sound absorption coefficient (ast), sound absorbing materials, reverberation time, acoustic silencers, mufflers, barriers, vibration and impact isolation

Unit– VII: Environmental Impact Assessment

Aims and objectives, basic concepts of environmental impact statement (EIS), framework of EIA, description of environmental setting, approaches for developing list of environment factors, pre-project, operational and post-project environment impacts.

Methods of EIA; adhoc procedures, checklists, matrices, networks.

Qualities of a good method, evaluation of efficiency of methods, comparative studies on methodology.

Prediction and assessment of impact on the land, air, water, noise, biological and socio-economic environments.

Public participation and preparation of environmental decision-making. Preparation of environmental management plan and criteria for selection of environmental factors, alternatives.

International Organization for standardization (ISO): Duties and function, basic total quality management concept, techniques and implementation requirements.

ISO 9001 and development of ISO 9000 series, historical background and benefits of ISO 9001, clause analysis of ISO 9001.

ISO 14001, explanation of ISO 14000 series, EMS and its benefits, formulating environment policy exercise, preparation ground for development EMS-Initial environmental review and exercise of identification of environmental aspects, clause analysis of ISO 14001, explanation of PDCA cycle, comparison of ISO 14001: 1996 and ISO 14001:2004, training need identification and communication and a role play exercise, audit process preparation and planning, opening meeting, audit investigation-interview techniques and nonconformities, closing meeting and follow up, attributes of an auditor and psychology of auditing and role play exercise, selection of audit team, checklist preparation, audit reporting, certification process and certification bodies, legislation pertaining to ISO 14001 documentation-preparation of L/R, emergency preparedness and response and a role play exercise, comparison of ISO 9001 and ISO 14001, comparison of ISO 14001 and OHSAS-18001.

VIII: Solid Waste Management

Solid Waste Management: Introduction, Municipal Solid Waste Management in India: Issues and approaches, Engineering principles; Sources, nature and characteristics; quantitative and qualitative; Solid waste problems: Industrial, Mining, Agricultural and Domestic (urban) wastes, waste processing techniques, Hydrological aspects of solid waste. Regulatory aspects of Solid Waste Management. Solid waste disposal: Sanitary landfill planning, site selection, design and operation, equipment, costs, Aerobic landfill stabilization. Biological oxidation. Composting, optimum conditions for composting, Biogas

Pyrolysis; Incineration: waste characterization, combustion calculation, unit operations, supply of air, products of combustion, furnace temperature, furnace calculation, storage of refuse, waste reduction and environmental control.

Industry specific solid waste management, Agriculture, Process Industry, Mineral and Metallurgical industry, Disposal of industrial and mill tailings, Resource and energy recovery: Recycling of solid waste, Integrated waste management.

Unit-IX: Biostatistics and Computer Applications

Introduction and importance of Biostatistics, Data collection and categorization; primary and secondary data, development of Questionnaire.

Sampling and sample design: Introduction; census and sample methods, Random sampling and Non-random sampling methods. Size of samples; Merits and limitations of sampling. Application of samplings in ecological and environmental monitoring studies.

Classification and tabulation of data: Frequency distributions, Types of Tables, Diagrammatic and Graphic presentation, General rules for constructing Diagrams. Logarithmic graphs; Frequency distribution graphs. Limitations of diagrams and graphs. Measures of Central tendency and dispersion: Characteristics of average- Geometric Arithmetic and Harmonic mean; Median and Mode.

Skew ness and Computer application : Windows XP, MS Word, MS Excel, MS Power Point, Adobe Page Maker, Adobe Photoshop kurtosis & measures of dispersion probability, Testing of hypotheses; level of significance, Critical region; degrees of freedom; Standard deviation, Standard error, Coefficient of variation.

Students test; `F' test; Chi-square Test; Analysis of Variance (ANOVA), Correlation and regression: Type of correlation; scatter diagram; simple graph; Coefficient of correlation; regression significance.

Applications of linear regression correlations; Establishment of allometric equations; Non-destructive methods of measurement of biomass and productivity, Application of computers in the Environmental Studies.

Computer application : Windows XP, MS Word, MS Excel, MS Power Point, Adobe Page Maker, Adobe Photoshop

Unit-X: Conservation Ecology

Definition of conservation, postulates of conservation biology.

The origin and evolution of living organisms, the invasion of unoccupied ecological niches, Adaptive radiation, genetic plasticity a factor in evolution.

Natural selection; self replicating molecular assemblages, limiting factors and tolerance curves, rules of inheritance for life on earth, Mendelian genetics, nature versus nurture, selfish genes, population genetics, maintenance of variability, genetics and ecology of extinction.

Ecosystem fragmentation and edge effects, concept of keystone species, Effects of species deletions and additions and invasive species on the maintenance of biological diversity, stability and complexity in relation to development, Methods of conservation of living resources; red and green data books, genetic resources, world conservation strategy.

Survey, monitoring and conservation of biological resources, sampling populations for biological conservation, collection and analysis of inventory data, criteria on choice of species for conservation.

Energy sources; conservation and management of non-renewable fossil fuel resources strategies for management of nonrenewable reusable mineral and metal resources. Conservation of biological resources; *in-situ* and *ex-situ* conservation strategies, captive breeding botanical and zoological gardens; design and management of protected area for wildlife conservation.

Cultural significance of natural protection

Introduction to environmental laws with reference to conservation

Modern concept of conservation

Forest and water resources and their conservation and management

WOOD SCIENCE AND TECHNOLOGY

Section A

WOOD PHYSICS: PROPERTIES OF WOOD

1. Physical properties of wood; density and specific gravity. Variation in density of early and late wood constituents. Effect of growth rings on density. Pith to peripheral density variations. Different modes of presentation in relation to moisture content. Physical properties of wood as influenced by moisture content and maximum moisture content of wood. Specific gravity of wood substance.
2. Thermal properties of wood-thermal expansion, specific heat, thermal conductivity and diffusivity. Change of temperature in wood under heating. Effect of moisture on thermal properties. Thermal properties of wood composites. Dimensional changes on heating green wood. Effect of dry and wet heat and heating in presence or absence of air on strength and dimensional stability.
3. Electrical properties of wood. DC electrical conductivity-effect of moisture content, temperature and extractives. Activation energy associated with electrical conduction. Electro-osmosis in green wood. Voltage breakdown strength. Dielectric properties of wood under alternating current and electro-magnetic field conditions. Effects of sp. gr., moisture content, temperature and extractives. Principles of induction and dielectric heating.
4. Piezo-electric properties of wood and its applications. Response of defects to stress waves in timber. Sound transmission and acoustics in buildings.

WOOD PHYSICS: WOOD WATER RELATIONSHIPS

1. Equilibrium moisture content and hygroscopicity of wood. Crystalline and amorphous zones in cellulose and hydrogen bonding.
2. Thermodynamic aspects such as heat of wetting, sorption, sorption hysteresis, sorption under stress, theories of sorption and effect of extractives on sorption; Thermodynamic method of measurement of Fibre Saturation Point.

3. Effect of cell ultra-structure on anisotropy-radial pitting. Relationships with density and factors causing departures in there from.
4. Relative anisotropic changes and effect on cell ultra structure by extractives and pretreatments such as pre-freezing, polar and non polar liquid and cell wall bulking.
5. Flow of water in liquid-vapour form through wood. Flow channels, mechanism.
6. Theories and equations of flow through a permeating medium and through timber section: slip, viscous and turbulent flow. Permeability measurement of wood to water and its applications, specific permeability.
7. Capillarity in relation to wood capillary tension and liquid tension collapse. Forces involved in overcoming capillary tension.

WOOD CHEMISTRY

1. Chemical constituents of wood and bark; Cellulose: structure, chemical properties, effect of acids and bases; Hemi-cellulose: structure, chemical properties, effect of acids and bases; Variation of major constituents in different morphological regions of wood.
2. Extractives in some prominent timber species and their importance. Isolation of extractives from wood and bark and separation of secondary metabolites using chromatographic techniques.
3. Resins, oleo resins, gum oleo resins in some characteristic woods
4. Tannins: Introduction, structure and properties in characteristic wood and barks.
5. General account of spectroscopic techniques such as UV-Visible, IR, NMR and Mass spectroscopy with special reference to characterization of chemical constituents of wood and bark.

WOOD ANATOMY

1. The Importance of anatomical studies in areas of wood utilization- an overview.
2. Formation of wood cambium and its derivatives: peripheral and epical growth components, heart wood initiation.
1. Basic characteristics of important soft wood and hard wood species from various forest types and plantations of Indian origin; General features visible on logs, sleepers and converted material: sap wood, heartwood, growth rings, growth marks, colour, odor, taste, grain, texture, luster, figure and weight. Other components influencing wood quality such as knots, shakes, discoloration, deposition, gum, resins, calceration; Reaction wood and spiral grains.
2. Identification of wood using a hand lens- characteristics features.
3. Microscopic features of soft wood and hard wood. Characteristics, diagnostic features used in wood identification of five soft wood species (*Pinus roxburghi, P. wallichiana, Abies pindrow, Pecia smithiana, Cedrus deodara*) and twenty hardwood species (*Acacia nilotica, Albizia lebeck, Adina cardifolia, Anogeissus latifolia, Bombax ceiba, Colophyllum* spp., *Dalbergia sissoo, Dalbergia latifolia, Diptocarpus* spp., *Lagerstromia lanceolata, Mangifera indica, Morus alba, Palaqcium elipticum, Pterocarpus marsupium, Shorea robusta, Tectona grandis, Terminalia tomentosa, Toona ciliata, Holoptelia integrifolia, Michilia champaca)* of forest origin and their economic importance and end uses.
4. Wood anatomy in relation to properties of wood.
5. Assessment of wood quality in plantation grown timber; Juvenile wood and its tissue characteristics compared to mature wood.
6. Production Forestry: Clones, Clonal forestry – its merits and demerits.
7. Ultra structure of wood and its applications towards better understanding of anatomical and utilization aspects of plantation woods and other fibrous material.
8. Anatomical aids, different types of microscopes and photography attachments objectives and eyes pieces and magnification levels.

TIMBER MECHANICS: STRENGTH PROPERTIES

1. Brief account of isotropic, anisotropic, orthotropic material. Coordinate systems. Stress-strain relationships. Different type of stresses and strain. Simple shear, principle stress and Mohr circle diagram; Hook's law and modulus of elasticity, directional elastic constants; Non-linear behaviour of wood, hysteresis.
2. Bulk Modulus and Poisson's ratio; Shear forces and bending moments, stresses in beams, beam deflections, column buckling and torsional forces; Role of moisture on elastic constants.
3. Standard physical and mechanical tests on timber; Determination of suitability coefficients and indices of Indian timbers; Safe working stresses and end uses of timber species based on strength data; Classification of timber for various end uses; Specialized uses of timbers and BIS Standards.
4. Shrinkage: directional shrinkage and calculation of fibre saluration point.
5. Testing of specialized wood products, performance tests and method of evaluation for door shutters, joinery, furniture, packing cases, tool handles, agricultural implements and sports goods.
6. Theory of creep: Kelvin, Maxwell & Burger models, effect of level of loading, moisture content, temperature, dynamic humidity conditions & prefreezing on creep.
7. Fatigue and its characteristics, orthotropic elasticity of reconstituted wood based systems including creep in lignocelluloses panels.
8. Fracture Mechanics

TIMBER MECHANICS: TIMBER GRADING

1. Timber a biological material: various defects and their manipulation in logs and sawn form; Importance of grading in primary and secondary processing; Quantification of defects in softwood and hardwood logs and swan timber; Grading and its importance in various wood utilization sectors; Stage of grading and grading rules, commercial and structural grading; Grading for specific end uses such as railway sleepers, pallets and packing cases, cooling tower, and relevant standards; Visual grading: its merits and demerits: Stress grading and its relationship to non-destructive testing and their importance; Grading and its relevance for plantation and clonal material
2. Growth stresses in timber and their measurement. Influence on grading.

COMPOSITE WOOD: ADHESIVES

1. Introduction of linear and cross linking molecules, theory of adhesion, intermolecular, intra-molecular attraction, cohesion, adhesion and adherence. Application of adhesives: wood, plywood, laminated wood; Importance of colloidal state and rheological properties.
2. Application techniques of glues in relation to plywood, particle board, MDF, laminated woods; Optimization of glue setting parameters: pressure, temperature, time; Influence of moisture content, pH interactions, surface preparation, pre-treatments' fortifying, filling, extending, and spreading on glue bond strength.
3. Chemistry, application, properties & classification of adhesives – cold setting, thermo-setting and thermo-plastic adhesives, elastomeric adhesive, gap filling adhesives.
4. Natural glues: Animal glue, casein glue, blood albumin, soya bean and starch, silicate of soda glues; Synthetic glues: Phenolic and substituted Phenolic adhesives; Urea and melamine formaldehyde, epoxy & polyurethane adhesives. Polyvinyl adhesives.
5. Importance of viscosity and setting time of glues and adhesives.
6. Precautionary measures in formulation of glues, application techniques, curing factors of safety and hygiene. Protective gadgets.

COMPOSITE WOOD: PLYWOOD

1. Historical perspective of plywood making, merits and demerits of plywood and solid wood for diverse reasons and end uses; Veneering: peeling of logs and peeling characteristics of diverse range of soft woods and hardwoods; Equipment for peeling and stressing: spindle lathes and slicer. Modern developments including veneering of small diameter logs and core veneer; Geometry of knife for veneering in relation to wood species, optimum conditions of setting of peeling lathes and slicer; Quality of veneer obtained by peeling and slicing, defects in peeled veneer.
2. Veneer drying, types of veneer dryers, their application and relative merits; recommended drying times, temperatures, jet-air speeds and venting. Steam consumption. Shrinkage in veneer drying. Collapse and warp and their control. High temperature veneer drying, tenderizing of veneer.
3. Plywood manufactures processing: Jointers, splicer. Veneer jointing, splicing, repairing, spreaders, glue spreading, assembly pre-pressing, hot pressing, sizing, trimming, thicknessing and finishing; Pressing equipment: cold and hot pressing equipment; Preservative treatment of plywood and allied products. Glue-line treatment and treatment of finished products. Choice of glue compatible preservatives and fire retardant chemicals.
4. Manufacturing process, choice of material, species for Block Board and Flush Doors.
5. Test methods for plywood.

COMPOSITE WOOD: RECONSTITUTED WOODS

1. Homogenization and reorientation of woody mass, functional property improvement of lignocellulosic materials.
2. Manufacture of particle Board from various lignocellulosic materials; Particle generating machines; range of particle dimensions preferred. Particle dryers, drying times, temperatures and steam consumption. Size separating, sieving machines, adhesive selection. Resin blending of face and core particles; resin quantities. Face-core composition in board. Mat laying. Prepressing and hot pressing. Temperatures and curing times; Use of wax emulsion and hardeners in glue, pressing technique, sizing, sanding and thicknessing of board.
3. Properties of particle board - density, moisture content, modulus of elasticity and bending, internal bond strength in dry state and after accelerated ageing. Testing methods. End uses; New particles board products for specialized uses- Rice husk particle board, cement bonded board, bamboo mat board, OSB; Manufacture of fibre board and MDF; Properties of hardboard and MDF. Testing methods and end uses; Manufacture of LVL Laminated Veneered Lumber.
4. Test method for ligno panels as structural forms; Comparative account of properties of particle board, hard board, MDF, LVL as against solid wood products in the area of conservation of forest and growth of wood board industry.
5. Energy consideration and equipment costs of lingo-panels.
6. Molded ligno products.

COMPOSITE WOOD: LAMINATED WOOD

1. Scope and merits of laminated wood in comparison to solid wood as counter parts; Energy consideration in laminated wood in comparison to solid wood as structural engineer grade material; Dimensional stability considerations in laminated wood. Density averaging and shrinkage averaging concepts; Roles of dynamic pre-compression and its benefits in subsequent processing and for multispecies laminates; Choice of glues, assembly, cold pressing, HF gluing and curing; Pressing pressures and cooling cycle in press for stabilizing.
2. Choice of species and improvement of aesthetic and strength properties for load bearing structures; laminated wood from bamboo and bamboo laminates; Laminated wood from plantation species: Poplar, Rubber wood, Mango and *Alanthus excelsa*; Modified woods:

Densified wood, Compreg, Impreg, Wood-Polymer Composites - their preparation, properties and uses.
3. Edge glued material and its scope in areas of wooden flooring, doors, cabinet inserts, cabinets and furniture.
4. Tests methods such as block shear test for bonding strength and tensile test for finger joint strength.
5. Acoustic panels from laminated wood and sandwich forms; Densified laminated panels.

SAWMILLING AND SAW DOCTORING

1. Introduction to a wet mill: Layout of log yard, in-feed systems to log yard and to Head Rig. Measurement of log volume- dimension and inventories.
2. Saw milling equipment: Horizontal band saw, vertical band saw, frame saw and chipper canters. Cross cut saws, re-saws, head rig, log scanners, and BOF systems. Gantry equipment, conveyer systems. Sawing of logs prone to growth stresses, line bar system and gang sawing.
3. Economic conversion of logs, various interacting parameters and decision making. Timber scale; Comparison of sawing for logs of forest and plantation origin.
4. Various associated systems relating to sawn material including scribber deck and auto stacking; Saw blade geometry, ripsaw, cross cut saws, tensioning, leveling, straightening, brazing, and setting of saw blades using saw doctoring equipment; High strain thin kerf saws; Threshold energy considerations in wood cutting.

WOOD SEASONING

1. Objects and importance of wood seasoning; Recommended moisture content of seasoned timber for different end uses in different climatic zones, and permissible tolerances. Basis of the recommendations.
2. Factors affecting drying rate of timber: thickness, moisture content, temperature, relative humidity and velocity of the drying air, diffusion and permeability characteristics of the species, moisture gradients in timber section.
3. Seasoning defects: Their causes and prevention; Drying stress development: measurement of drying strains. Resultant plastic strains sets produced. Stress reversal and case hardening. Critical stages for surface and internal cracking. Warp control: Top weighting, calculation of optimum loading, spring loading system, reduced crossers spacing; Drying conditions: compression set, core strength, stress reversal and case hardening.
4. Special seasoning methods and pretreatments: Anti-shrink pre-treatment, their efficiencies, coldness shrinkage, chemical seasoning, pre-steaming, pre-freezing.
5. Seasoning and warp control in short rotation plantation timber species through width's thickness manipulations such as SDR.
6. Classification of Indian timbers according to refractoriness to seasoning
7. Air seasoning: Stacking, practice for poles, posts, railway sleepers and sawn timber. Orientation of stacks relative to wind direction. Fork lift trucks for stacking. Air seasoning sheds: Forced air drying; Kiln seasoning: General outline of kiln drying schedules. Optimum drying conditions, control at different stages of degrades development. Kiln drying times. Modification of schedule for higher thickness, lower initial moisture contents and special quality for end uses. Removal of casehardening. Reverse casehardening. Scope of accelerating a schedule. Equalization treatment; Energy conserving drying processes: solar kilns, dehumidification kilns, vacuum drying in vapor with heat recovery, vacuum drying in RF field etc. Comparative economics: air seasoning, steam heated and solar kilns.

WOOD WORKING AND WOOD FINISHING

1. Introduction to dry mill operations: Layout of wood workshop; Circular saw and range of jobs; General features and designs of wood working machines such as planner, thicknessor, mortiser, tenonner, molders, routers, turning lathes and drill-boring machines; General features of universal wood working machines, copying lathes, four side planner-cum-molder and CNC router; Saws for panel products, radial arm saws, cross cut-trim saws; Disc and drum sanders; Portable power tools and dowel making machines; Knife geometry, cutter profiles, carbide tipped cutters;
2. Elements of basic joinery, joints for furniture and joinery: tenon mortise, dovetail and mitre joints, their combinations.
3. Various wood machining defects, their occurrence in Indian woods and evaluation of Working Quality Index (WQI) and Carving Quality Index (CQI) ease of working, overall performance and quality ratings of important basic operations; Effect of machine parameters on quality of worked surface in basic wood working operations.
4. Nature of woody tissue, pre-finished surfaces and figure in wood. Infiltration of coloring material and its patterns; Filling, repeated sanding and staining operations using aniline based dye stains or other environment friendly techniques- use of bark saw dust extracts and ammonia fumigation; Finishing of Juvenile wood surface fibers; Priming and painting of wood and comparisons with polishing-lacquering –varnishing, oiling-waxing and buffing; Wood finishing equipment: brushing, spraying, electrostatic spraying, powder coating, UV curing. Precautions in the use of finishing materials with special reference to polyurethane finishes.
5. Performance tests on wood finishes and test methods: Role of moisture on pre-finished, finished wood surfaces, relative, solubility and washability of wood coatings by rain water. Photo oxidation effects. Electro kinetics of absorption and adsorption on surfaces. Moisture Excluding Efficiencies (MEE) of wood coatings.
6. Test for surface smoothness and gloss.

WOOD PRESERVATION:

1. Natural durability, durability of heartwood and sapwood. Causes for natural durability. Classification of timbers on the basis of natural durability; Nature and conditions of attack by various wood- bio degrading organisms on land and marine conditions. Estimates of losses of wood by bio-degradation in storage, processing and service.
2. Importance of wood preservation; Preservatives-preservative materials toxic to various bio-degrading agents- their toxicity levels. Bio-degradable preservatives. Eco-friendly preservatives; Requirement of an ideal preservative. Types of wood preservatives. Merits-demerits of different preservative compositions in relation to end use; Recommended preservatives: their penetrations and retentions for various end uses;Testing of the efficacy of preservatives under laboratory and field conditions; Qualitative and quantitative analysis of preservatives in their free condition and in the treated timber.
3. Field / Laboratory tests for preservative / wood durability evaluation.
4. Dependence of penetration and retention of preservative on wood structure and permeability. Preparation of timber for treatment. Treatability classification of timbers. Penetration indices.
5. Non-pressure / pressure treatment of wood, bamboo and thatch with reference to different end uses.
6. Preservation plants: Design, specifications, layout, operation, inspection, maintenance and economic aspects. Pollution aspects; Economics of preservative treatment.
7. Fire protection of timber: General principles of combustibility; application of fire retardant chemicals; methods of testing fire resistance.
8. Appropriate eco friendly treatments for handicraft products.
9. Fumigants.

TIMBER ENGINEERING

1. Broader definitions of Timber Mechanics and Timber Engineering and their inter relationships; Introduction to basic engineering tools free hand sketching, different types of lines, materials breaks, principle orthographic projections and dimensioning. Method of representing a section for various materials, Isometric view and detail of assembly drawing; Scope of Timber, bamboos, laminated wood and panel products in relation to concrete, steel, stone and plastics in Engineered constructions such as floors, walls, roofs, and grain silos.
2. Design of linear timber components beams, tiles, purlins, columns and chords; Trusses and Arches, their configuration. Analysis of simply supported, 2-hinged, 3-hinged types; Glue laminated linear and curved structural members; shear strength, analysis and design.
3. Strength Properties and classification of structural timber. Dimensional optimization for beams columns and associated structural dimensions in a product. Minimum dimensions of sawn timber essential for timber engineering design.
4. Strength Properties and design of structural timber joints. Changing trends and role of fastener's metal rings, connector plates, newer technologies in effect of defect of design and performance; Statistical aspects in relation to engineered structures and fastener systems.
5. Codal requirements for building material (wood, laminated wood, laminates) grading, proof loading, strength properties, moisture content, size effect - length, width, thickness, depth and presence of knots effecting tension, compression, shear stress systems ; National building code and its application with special reference to wood houses.
6. Prefabrication, do it yourself –knock down concepts in relation to engineered structures.
7. Scope of plantation grown material, silvicultural thinning, small dimensions timber beside poles in engineered structures.
8. Wooden Houses for hilly areas, log cabins, ecotourism; Retaining walls for hilly areas and slopes and their beneficial effects; Wooden culverts in forest areas and villages and canals.

PRODUCT DESIGN & FABRICATION

1. Design, ratios and proportions, projections and anthopometric aspects; Visual grading, colour grading in fabrication of a product; Use of twigs, branches, roots, knots, and feature grade material including worm wood in making of "new wave" products.
2. "Windsor chair" as a classic example of time tested multiple utility and dynamic trendsetter.
3. Behaviour of Furniture, cabinets, wall panels, wooden floors, table tops, wooden doors in warm and humid climates and weather-climate related fluctuations. Movement or working in wood; Method of estimating movement of different timber species and panel products; "System or product movement" and measures to contain them in a joint, solid wood door and a table top.
4. Role of various nails, screws, and fasteners corrugated pins, and dowel pins along a design, with or without association of a joint. The net gain or benefits of these aspects.
5. Forces operating on an upright Timber chair calculation of bending moment on back to side rail connecting joints. Possible design improvements, material selection and production aspects.

CERTIFICATION AND NANO TECHNOLOGY

1. Basics of nano-science and its utility for forest and forest products sector
2. Forest certification: Forest and forest products certification – basics and importance; Schemes of forest certification; Environmental certification and eco-labeling
3. Climate change: Carbon sequestration and climate change –introduction
4. Carbon credits and possibilities in timber, timber products and processes

Section B
of Wood Science & Technology

Physics:

Physics of Materials
Solids; Amorphous and crystalline materials. Lattice translation vectors. Unit cell. Reciprocal lattice. Crystall diffraction: Bragg's law. X-rays diffraction of crystals.
Lattice variations. Linear monoatomic and diatomic chains. Acoustical and optical phonons. Qualitative description of the phonon spectrum in solid. Brillouin zones.
Dielectric properties of matter: Electric susceptibility, polarizability, Clausius-Mosotti equations, classical theory of electronic polarizability
Viscosity, Poiseuille's equation; Van der Waal's interaction, hydrophobic interactions

Atomic Physics: Atoms in electric and magnetic fields: Electron spin, Spin and orbital angular momentum, space quantization and Larmor's theorem, Stern-Gerlach experiment, Magnetic moment of the atom, Gyromagnetic ratio and Bohr Magnetron
Atoms in external magnetic fields: Zeeman effect (Normal and anomalous)

Thermal Physics: Thermodynamic description of system: Zeroth law and thermodynamic temperature; First law and internal energy, conversion of heat into work, reversible and irreversible processes. Second law and entropy, Carnot's cycle and theorem, entropy changes in reversible and irreversible process, Entropy diagrams and equations, Unattainability of absolute zero, third law of thermodynamics; Joule-thomson effect-production of low temperature; Claisius-Clapeyron Equation

Kinetic Theory of gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path; Law of equipartition of energy and its application to specific heat of gases; monoatomic and diatomic gases; Transport Phenomena: viscosity, conduction and diffusion

Heat transmission: Mode of heat transfer, Searle's and Lee's experiment, black body radiation, Planck's law, Rayleigh Jean's Law, Wein's displacement law, Stefan-Boltzmann law

Statistical Mechanics
Micro and Macro states, energy states, energy levels, degenerate energy levels, degenerate gas, phase space, concept of entropy and thermodynamic probability.
Classical statistics: Maxwell-Boltzmann distribution law, thermodynamics of an ideal monoatomic gas, classical entropy expression, Gibb's paradox
Quantum statistics: Ideas of Bose Einstein statistics and Fermi Dirac statistics

Oscillations and waves
Simple Harmonic motion: Simple Harmonic Oscillator, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring, energy in simple harmonic motion. Superposition of two SHM: (i) collinear SHM of same frequency (ii) collinear SHM of different frequencies – phenomenon of Beats (iii) SHM of same frequency but perpendicular to each other and (iv) Lissajous figures.
Damped Harmonic Motion: Equation of motion, Dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor.
Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, quality factor.

Coupled Oscillator: Degrees of freedom, coupled oscillator with two degrees of freedom; Normal modes; General method of finding normal modes for a system of two degrees of freedom.
Wave Motion: One dimensional plane wave; Classical wave equation; Superposition principle; standing wave on a stretched string (both end fixed)

Chemistry:
Inorganic Chemistry:
General principles of Metallurgy: Method of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn); electrolytic, oxidative refining.
s- and p- Block Elements: Periodicity in s- and p- block element, w.r.t. electronic configuration
Compound of s- and p- Block Elements: Concept of multicentre bonding (diborane). Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH). Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2
Inorganic Polymers: Borazine, silicates and silicones
Transition elements (3d series): General group trends with special reference to electronic configuration, variable valency, ability to form complexes and stability of various oxidation states. Oxidation states, Magnetic properties.
Chemistry of 3d metals: Oxidation states displayed by Cr, Fe, Co, Ni and Co.
Coordination chemistry: Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). IUPAC system of nomenclatures.

Organic Chemistry:
Addition reactions: Alkenes and alkynes (upto four carbon atoms): Hydrogenation, halogenation, hydrohalogenation, hydration. Aromatic hydrocarborn, Aldehydes and ketones – addition reaction
Substitution reactions: Alcohols, phenols and amines. Carboxylic acid and derivatives: hydrolysis.
Reduction reactions: Reduction of aldehydes and ketones by catalytic hydrogenation, Reduction of aromatic nitro compounds by electrolytic reduction.
Rearrangement reactions: Fries rearrangement
Polymers: Definition of monomers and polymers. Classification of polymers. Natural rubber. Development of biogradable polymer viz., polylactic acid and polyhydroxybutyric acid.
Amino acids, peptides and proteins: Amino acids, peptides and proteins, Natural amino acids and essential amino acids.
Carbohydrates: Carbohydrates: Classification, nomenclature of carbohydrates. Determination of configuration of monosacchrides. Structure of glucose, fructose and cellulose
Alkaloids

Physical Chemistry:
Liquids: Surface tension and its determination using Stalagometer, Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer, Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).
Systems of variable composition and solutions:- Solutions: Thermodynamics of ideal solutions, Partial miscibility of liquids, Immiscibility of liquids, Principle of steam distillation, solvent extraction; Colligative properties of dilute solutions: Thermodynamics of dilute solutions, Colligative properties of electrolytic solutions, van't Hoff factor and its applications.
Chemical equilibrium and phase equilibrium:- Chemical equilibrium: Van't Hoff equation, Calculation of equilibrium constants from thermodynamics measurements.
Conductance and electrochemical cells: Reversible and irreversible cells, Measurement of EMF of a cell, Nernst equation and its importance. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations- qualitative treatment (acid-base and oxidation-reduction only)
Atomic structure, **Chemical bonding and molecular structure:-** Ionic equilibria**:** Ionization of weak acids and bases, pH scale, common ion effect, Buffer solution. Solubility and solubility

product of sparingly soluble salts- applications of solubility product principle. Qualitative treatment of acid-base titration curves. Theory of acid-base indicators.

Fundamentals of organic chemistry: Concept of hybridization of carbon. Cleavage of a covalent bond; homolysis and heterolysis.
Intermolecular and intramolecular hydrogen bonding. Effect of intermolecular and intramolecular forces on properties such as solubility, vapour pressure, melting and boiling points of organic compounds.
Stereoisomerism:- Optical isomerism: Optical activity, plane polarized light, specific molar rotation, chirality, enantiomerism, disteroisomerism, racemic mixtures and their resolutions by salt formation method; Geometric isomerism: Cis- and trans- system for geometrical isomers. E- and Z- notations for geometric isomers; Qualitative treatment of stability of chair and boat conformations of cyclohexane.
Chemical kinetics and photochemistry: -The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction; Photochemistry: Lambert-Beer law, Laws of photochemistry, Quantum efficiency and reasons for high and low quantum yield. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions; Surface chemistry and polymers: Adsorption by solids. Langmuir theory of adsorption of a gas on a solid. Langmuir adsorption isotherm.

Elementary concepts of biological sciences
Botany: Diversity of plants, classification, brief study of algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms. Morphology of root, stem and leaf; Importance of forestry, botany in Wood Science and Technology; Bentham & Hooker system of plant classification with reference to timber yielding families; Name changes/ Nomenclature of commercial tree species and its significance in judicious utilization of timber; Field characters of 10 families of timber important trees with emphasis on dendrological diagnostics i.e. bark, blaze, bole, crown, branching, flowers, fruits, etc.
How to consult Forest Flora for proper identification of timber yielding trees.

Timber Entomology: General introduction of insects and their body parts, head, thorax and abdomen, metamorphosis of adult larval mouth parts and caterpillars; Population dynamics, natality, mortality and endemic growth; Forest insects and broad classification. Wood borers of standing trees, logs and converted materials for prominent species, Oak*, Juniper, Shoreas, Dipterocarpus, Toona cialiata, Dalbergia, Artocarpus* and *Ficus* species beside *Pines*; Leaf defoliators and their effect on forest and plantation species; regardless of durability of timber species; Termites, their identification, life history and distribution in forest lands, plantations and built structures. Termite resistance tests and termite control; Biological control of insects and pests, pests control components, principles and practices. Integrated pest management, Economics of pest control; Insect fungi interaction, microbial control, insect behavior regulators and forest hygiene; Laws of Quarantine and phyto-sanitary certification.

Wood Microbiology: Biodegradation and biodeterioration and broad idea about microbes involved in wood deterioration; Biotic and abiotic factors involved in attacking timber products ranging from logs, planks, wood chips, exterior and interior furniture and joinery products, plywood, MDF, particle board and bamboo products; Taxonomy of wood decaying fungi; Essentials of fungal attack on lignocellulosic material like solid wood; Types of fungal degradation of wood, bamboo and their products; Physical, chemical and microscopic effects of decay, soft rot and discoloration; Fungal decay in wood in buildings; Natural decay resistance of wood & its assessment using accelerated laboratory tests; Quarantine regulation of import of timber.

Pulp & Paper Technology

1. FORESTRY

1.1.General: Forest types of India, Bamboo forests their composition, distribution and Physiognomy importance of forests for supplying raw materials to various industries, Nature and functions of social forestry, farm forestry - their social and physical interactions as an integrated system.

1.2. Forestry operations: Temporary and permanent nurseries. Planting –operations and practices.

1.3 Silviculture: Natural and artificial regenerations, Silvicultural systems, Thinning, Regeneration of harvested area.

1.4 Forestry management : Coverage of common problems met in organizing forest properties, objects of management, Normal Forests, Age gradations and their distribution, Rotation yield regulation.

1.5 Non- woody Fibrous materials: Distribution, Occurrence, availability like bagasse, cotton linters, Jute, hemp, cereals, straws etc.

1.6 Timber Harvesting and Transportation : Harvesting methods, Felling age, Timber marking and Transportation to Depot, grading of logs.

1.7. Wood Handling: Measurement of wood, Wood stacking, Effect of storage on pulp & paper making.

1.8. Deterioration of wood: Physical and biological deteriorations, Deterioration by fungi, termites, Beetles, etc.

2. PULP TECHNOLOGY-I

2.1 Introduction to Pulp and Paper Technology:

History of Pulp and Paper making in India, Status of paper Industry in India, Brief description of pulp and paper making processes, Selection and availability of paper making raw materials, Introduction to debarking, chipping, pulping washing and bleaching processes, Introduction to recovery processes i.e, Evaporation, Iincineration, Causticization.

2.2 Paper making raw materials:

Classification of Fibrous raw materials with example woody and non-woody raw materials. Structure of wood (Hardwood &softwood) and their cell types. Structure of non-woods and their cell types.

2.3 Fiber Morphology :

Structure of fiber, Fiber dimensions and its effect on pulp and paper making & processes .Morphological analysis of fiber (Quantitative), Chemical constituents of fibrous raw materials and their significance .

2.4 Chemistry of Fibrous raw materials:

2.4.1 Cellulose:

Isolation and structure of cellulose, Chemical properties of cellulose, Reactivity of cellulose Swelling of cellulose. Addition and substitution reactions of cellulose. Degradation Reactions –Hydrolytic degradation, Oxidative degradation, Microbiological degradation of cellulose derivatives.

2.4.2 Hemi-cellulose:
Structure of hemi cellulose Distribution of hemi-cellulose in plant cells (fiber). Structure of hemi-cellulose eg. Xylans. Analysis of xylans glucomannons etc. Importance of hemicelluloses in paper making.

2.4.3 Lignin:
Introduction to Lignin structure. Different Types of linkage in lignin. Properties of lignin–physical and chemical reaction of lignin during alkaline process. Halogenation of lignin, reaction of lignin during bleaching.
Extractives : Isolation and structure of wood extractives. Effect of extractive on papermaking process.

2.5 Practical:
- Wood Anatomy: Identification.
- Fiber, Identification and tissue analysis (properties of fibers, vessels, rays, parenchyma) and determination of dimensions.
- Proximate chemical analysis.
- Determination of α, β and γ cellulose, silica in raw materials.

3. PULP TECHNOLOGY –II

3.1 Fibrous raw material preparation:
Preparation of Conventional Fibrous raw material, debarking of wood, chipping and its conveying, screening and storage of chips. Cleaning, Chipping of bamboo and its screening, washing and storage.

3.1.1 Straws and Grasses:
Cleaning, washing and other pretreatment for removal of extraneous substances, storage of straws and grasses.

3.1.2 Bagasse:
Depithing, storage and prophylactic treatment.

3.2 Types of chippers, Chips screens and chip conveying system.

3.3 Alkaline pulping:
Standard Terms Used , Analysis of Alkaline cooking liquor , Principles of batch pulping technique, Types of digesters- batch and continuous and their operations. Impregnation techniques and cooking operations, Process variables, blow heat recovery systems, characteristics of kraft pulps, kraft odour emissions and its reason .

Soda Pulping:
Brief descriptions of conventional techniques for soda pulping of bagasse ,straws & kenaf etc. Type of batch and continuous digesters used for soda pulping.

3.4 Dissolving grade Pulps: Characteristics of dissolving pulps, Processes for dissolving grade pulp .

3.5 Sulfite pulping: Standards terms used, cooking liquor composition and its analysis, sulfite cooking, operation, bases used and their comparison, Effect of process variables, Multistage sulfite pulping techniques .Modifications in sulfite pulping techniques .

3.6 Mechanical Pulping:

3.6.1 Stone ground wood process – Process and equipment .Grinding mechanism. Types of grinders and their operations. Process variables. Pulp characteristics and their uses. Limitations of the process.

3.6.2 Refiner mechanical pulping- Process and equipment. Mechanism of refining. Types and designs of refiners. Refining conditions. Pulp characteristics and their uses. Advantages and limitations of the process.

3.6.3 Thermo mechanical and chemi thermo mechanical pulping: General principles. Process and equipment and their uses. Environmental effects of TMP and CTMP.

3.6.4 Chemi mechanical pulping: Process and equipment. Various chemicals used, composition of cooking liquor. Process variables. Pulp characteristics and their uses.

3.6.5 Semi chemical pulping: Process and equipment. Various chemicals used, Composition of cooking liquor, Process variables, Pulp characteristics and their uses.

3.7 Practical:

- Raw material preparation- Chipping, chip classification, measurement of dimensions, chip density, bulk density.
- Depithing of bagasse.
- Analysis of white liquor.
- Pre hydrolysis of kraft and soda pulping.
- Pulp analysis- Kappa number, viscosity and lignin.
- Refiner mechanical pulping.
- Semi-chemical and chemi-mechanical pulping.
- Fiber classification.

4. ELEMENTS OF MECHANICAL AND ELECTRICAL ENGINEERING

4.1 Steam: Generation and use of wet, dry and super heated steam, Dryness fraction, Enthalpy (Total Heat) of steam, specific volume, external work, external energy. Use of steam table and charts.

4.2 Steam boilers: Fire tube and water tube boilers, high pressure boilers mountings and accessories. Capacity and efficiency of boilers, Boiler Act and rules.

4.2.1 Furnace: Types and method of fuel firing.

4.2.2 Draft: Definition, Natural and Artificial draft, Calculation of Chimney height and H.P of Draft fan.

4.2.3 Fuel and Combustion: Different fuels and their calorific value, products of combustion.

4.3 Steam Turbine: Introduction, Classification, Impulse and Reaction turbine, Compounding for pressure and velocity.

4.3.1 Steam to Power Cycles: Back pressure, Extraction cum condensing and extraction cum back pressure turbine.

4.3.2 Cooling Device: Spray pond and cooling tower.

4.4 Boiler feed water treatment: Treatment methods and specifications of boilers feed water.

4.5 Ferrous and non ferrous metals: Classification of Iron and Steel, Cast Iron and their alloy, Steal and their alloy, Copper, Zinc and their alloy, Nickel and Chromium alloys, properties and applications.

4.6 Metal Forming: Casting, Forging, Welding, Soldering and brazing, advantages and applications.

4.7 Heat Transfer: Method of heat transfer, radiation, conduction and convention, heat exchanger types and application, rate of heat transfer, overall heat transfer coefficient, thermal insulation, selection of insulating materials.

4.8 Transmission of power: Belt and gear drive type and applications.

4.9 Fluid Mechanics: Fluid pressure, density, specific weight, specific gravity, viscosity and their measurement. Flow of liquid, flow throw pipes, loss of head in pipes, mechanism of fluid flow, Reynold's number, Laminear and Turbulent flow, velocity profile.

Fluid machines, Centrifugal / Reciprocating pumps, vacuum pumps, design and applications.

4.10 Electrical circuits: Single-phase and three-phase circuits, Star and Delta connections, power in single phase and three phase circuits, Earthing of equipments.

4.11 Electrical Machines: Three phase Induction motors, D.C Generators and motors their industrial applications. Speed control of D.C motor.

4.12 Introduction to Energy Sources: Steam and power requirement in pulp & paper industry, co-generation, co-generation economics.

5. Pulp Technology-III

5.1 Screening and Cleaning: Undesirable constituents in the unscreened pulp. Objectives and mechanism of screening, efficiency and its calculations. Particle properties affecting screening efficiency. Variables affecting screening of operations. Types of screens and their process designs.

5.2 Centrifugal Cleaner: Theory and Operation, variables affecting centrifugal cleaning. Types of centrifugal cleaners.

5.2.1 Screening Systems: Combination of screens, combination of centrifugal cleaners, process flow sheets of centrifugal cleaners.

5.3 Washing: Objectives of pulp washing, principle mechanism used in drum and diffusion washing. Physiochemical aspects of lignin removal in washing, operation of brown stock washing systems.

5.3.1 Measurement of Washing Performance: Displacement ratio, washing efficiency, Dilution factor, washing losses etc., Factors affecting pulp washing.

5.4 Pulp washing equipments: Types, construction details and operational principles.

5.5 Practical:

- Determination of soda losses.

PAPER TECHNOLOGY – I

1.1 Beating and Refining: Introduction to paper making & Stock preparation Beating & Refining action structure of fiber, Effect of refining on fiber, stock web and paper properties. Measurement of refining, Quantification of refining action, Concept of Spectic Edge Load.
Process variables during refining controlled variables, conventional variables Active and passive process variable calculations on Refiner parameters

1.2 Wet and Dry strength additives: Introduction to Wet and additives additives, Rosin, sizing, rosin size preparation, fortified size, Dispersed size, factors effecting sizing, measurement methods of sizing synthetic size. Wet Strength additives, mechanism of wet strength development. Handing of wet strength broke, Dry strength Additives, Starches, Different types of starches and their modification . Application of starch CMC and Gums in surface sizing as Wet end additive and Coating

1.3 Fillers and Dyes: Introduction to fillers, addition of filler and retention phenomena, effect of Fillers on paper properties. Introduction to dyeing. Principle of light interaction with paper Different type of dyes and their application in paper.

1.4 Equipments: Design and construction of stock preparation, equipments including Beaters Conical and Disc-refiner. Stock chest and agitators etc..

1.5 Practical:
- Determination of pulp consistency, °SR and CSF.
- Beating and refining at laboratory beater and refiner.
- Stock sizing and evaluation of paper properties.
- Analysis of rosin and alum.

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1. **PAPER TECHNOLOGY –II**

2.1 General overview of papermaking Process : Definition, importance and regulation of Consistency regulators and point of controls in system, consistency regulators.

2.2 Approach Flow System: Significance and function of constant level box . Fan pump – function and characteristics. Need for cleaning stock and principle of cleaning system used in paper industry centri-cleaners systems for cleaning pulp stock. Selection of Approach flow system for various machines .

2.3 Headbox –Function design and types. Level control system. Components of headbox. Function of slice types. Adjustment of slice. Jet geometry and speed in papermaking .Relation between formation and jet placement.

2.4 Four Drainer Table: Components of a four drainer table and their function. Theory of sheet formation –Drainage, thickening, filtration, orientation due to Shake, Brest roll, forming board, table roll, hydrofoils, wet and suction boxes. Suction boxes function and vacuum control, forming fabrics. Couch roll function, Design features. Dandy–functions structure.

2.5 Webs transfer: Open, pickup, Lick-up, draw control. Importance of draw and effect features.

2.6 Cylinder mold formation: Uni and counter flow cylinder formers.

2.7 Stock and white water system: Short circulation, large circulation, fiber recovery through saveall.

2.8 Advances in paper former: Twin wire former- roll former, blade former, hybrids, top former.

2.9 Practical:

- Laboratory Sheet making and Drying.
- Back water analysis, Single pass retention.
- Fiber loss analysis.

2. **PAPER TECHNOLOGY- III**

3.1 Wet Pressing: Requirement and limitations, description of plane, fabric, suction presses, theory of pressing, press arrangement. Factors affecting water removal at presses, Nip pressure and loading of presses, cambering of press rolls, press-felt functions, press-felt making, felt cleaning and conditioning, Advances in press section.

3.2 Drying of Paper: General description of dryer parts, multi-cylinder and Yankee-dryer, effect of drying on sheet properties. Theory of drying, mechanism of heat and mass transfer, Dryer felts and fabrics, steam supply and condensate removal, hood system of dryers- ventilation and air supply, operation and control of dryers. Drying methods- Air drying, IR drying, development in dryers and drying methods, CD moisture profile- reasons of unevenness and methods of control.

3.3 Paper Machine Drives: Type of drives, operators control functions, power requirement for different sections of paper machine.

3. PLANT & EQUIPMENT DESIGN

4.1 Introduction to plant and equipment Design: - Process selection .Development of a process from Laboratory and pilot studies .Commercial plants Selection of equipment, selection of suitable materials of construction.

4.2 Plant Location, site preparation .plant layout, plant installation and operation.

4.3 Economics analysis of project: Capital cost estimation, Manufacturing cost estimation, sale price, profitability analysis.

4.4 Environmental consideration in plant design.

4.5 Design and construction of chipper, chip screens, pressure vessels (digesters), Process equipments like evaporators, refiners, centri-cleaners, screens, stock chests and agitator, stock pump. Design of paper machine parts, Design and selection of pipe lines for different fluids, piping layout and support.

4. PAPER TECHNOLOGY- IV

5.1 Calendaring: Principle of operation. Factors affecting the working of Calendar. Machine and Super Calendar. Effect of calendaring/super calendaring on properties of paper. Calendar hardware description. Crowning of calendaring rolls. Swimming rolls.

5.2 Re-winder and sheeters: Equipment components & Defects developed during operation. Quality checks in the finishing house.

5.3 Coating of Paper: Application of coating for paper and paper board, basic components of any coating, coating application methods, coating drying.

5.4 Description of Process of lamination. Extrusion coating, Carborizing, making tracing papers, ammonia papers.

5.5 Practicals

- Preparation and testing of coating formulation.
- Printing test and print evaluation.

5. IN PLANT TRAININGS

The aim of this course is to provide the students an opportunity to understand the actual working environment of a mill. The student will be sent to mills after IInd semester examination for two months training. The students will utilize the opportunity in understandings the mill operating conditions, equipments and process details, and to get an in sight into the over all working of the organization. Student will go to different section of the mill to get a fair idea of their working. The student will maintain a detailed daily diary recording. Their observations, equipments and process details, material and energy flows, instruments etc. Each student will submit a consolidate mill training report, given mill process flow sheets, equipments and other relevant data of the mill visited.

1. PULP TECHNOLOGY – IV

1.1 General Principles of Bleaching: Objectives of bleaching, bleach-ability and its measurement, brightness reversion. Bleaching of Chemical pulps -single stage and multistage. Bleaching processes viz. chlorination, extraction, Hypochlorite and chlorine–dioxide. Chemical reactions and process parameter at each stage. Calculation on bleaching of pulp.

1.2 Bleaching of Mechanical and Semi- Chemical pulps –Brief study of dithionite and Borohydride bleaching techniques. Brief description of bleaching equipments and their material of construction. Preparation of Hy-pochlorite, chlorine dioxide, and peroxide bleach liquor and their analysis. Instrumentation and process control in bleach plants. Introduction to nonchlorine bleaching process.

1.3 Environmental aspects of bleaching: Oxygen, ECF and TCF bleaching.

1.4 Practical:
- Bleaching of Pulp- Single Stage and Multi-stage.
- Bleached pulp evolution.

2. CHEMICAL RECOVERY

2.1 Properties of black liquor : Chemical, Physical, Physico - chemical transport, thermal and polymeric properties.

2.2 Black Liquor Oxidation: Necessity, Chemical reactions, parameters affecting the black liquor oxidation. Calorific value of black liquor. Disilication of black liquor- sources of silica, its affect on concentration and incineration, various process available and their description.

2.3 Concentration of Black Liquor: Indirect types, types of evaporators along with construction details, merits and demerits., steam pressure and vacuum, feeding sequence, steam requirement, steam economy, heat transfer area, single effect and multiple effect evaporators, factors affecting number of effects.

2.4 Cooling Devices: Surface condenser and direct condenser, cooling water requirement.

2.5 Direct contact evaporators: Principle, types, advantages and disadvantages, construction details, water evaporation calculations, cyclone separator, operating principle and type.

2.6 Incineration of Black Liquor: Process Chemistry, reaction involve, parameters affecting the incineration process, type of recovery furnace. Roaster and smelter. Type of incineration equipments, chemical reactions in recovery furnaces. Heat and chemical balance. Electrostatics precipitators – construction and operation.

2.7 Causticizing of Green Liquor: Green liquor treatment and classification, slaking and causticizing reactions, caustisizing equilibrium. Variables affecting the causticizing efficiency. White liquor classification and equipment details, mud washer and filtration equipments, soda loss in lime sludge, lime mud re-burning and lime recovery, lime kiln details, flue solid re-burning system, material and energy balance.

2.8 New Chemical Recovery System: Process description and salient features of new recovery processes such as DARS, WAO, Broby recovery etc. Alternative uses of black liquor i.e, production of lignin derivatives and their process details.

2.9 Practical:
- Analysis of lime and lime sludge.
- Water analysis- Total solids, hardness and pH.
- Analysis of black liquor.
- Analysis of green liquor.

3. MATERIAL AND ENERGY BLANACE

3.1 Introduction: Unit and Dimension, Moles, Density, Concentration, Temperature and Pressure Composition, Relation, Stoichiomertry and Chemical Equations. Ideal Gas Laws, Equation of states for non ideal gases.

3.2 Material Balance: Law of conservation of mass. System boundaries and surrounding. Tie elements, Recycling, By-pass and Pursing streams. Examples of Material balance with out chemical reactions.

3.3 Vapour liquid equilibrium: Vapourization, Condensation, Vapour pressure. Effect of Temperature and Pressure, Vapour Pressure Plots, Saturation, Multicomponent Gas Liquid Equilibrium. Steam tables and their use.

3.4 Definition of various energy related terms. Heat capacity and its estimation, Koop's rule. Calculation of Enthalpy changes with and without phase change. Latent Heat of Vaporization. General energy balance equation. Mechanical energy balance with chemical reaction, standard heat of formation and combustion. Heat of reaction at constant pressure and volume. Effect of temperature on heat of reaction at constant pressure.

3.5 Psychometric: Definition of DB, WB, Absolute humidity, Humid Volume, Humid heat etc. Use of Psychometric Chats and its application.
3.6 Fuels: Combustion of different types of fuels, GHV, NCV, Proximate & Ultimate Analysis.
3.7 Example of martial and energy balance related to pulp and paper industry.

4. PAPER TECHNOLOGY –V

4.1 Introduction and use of various grades of paper. Importance of paper properties and property requirement. Description of properties, measurement, equipment, calibration, reporting of results etc.

4.2 General Properties: Two sidedness, bidirectionality, basic weight, caliper, bulk, dimensional stability, curl, smoothness and porosity.

4.3 Strength Properties: Breaking tensile strength, compression strength, burst, tear, foldering endurance, stiffness.

4.4 Optical Properties: Light sheet interaction, reflectances, scattering coefficient, opacity, brightness, gloss, colour/ shade.

4.5 Barrier/ Resistance Properties: Penetration of water/ oil through paper, water resistance, water absorbency, water vapour permeability, oil/ grease resistance.

4.6 Effect of environment on properties: Interaction between paper and moisture, effect of moisture on strength and general properties on paper shape and dimension. Standard conditions of paper testing. Conditioning of paper prior to testing.

4.7 Statistical Evaluation: Statistical aspects of testing, confidence limit, reliability of test.
4.8 Practical:
- Identification of wire side/ top side and MD/CD of a paper sample.
- Determination of gsm, thickness, bulk and density of paper sample.
- Determination of moisture and ash content of paper sample.
- Determination of sizing of paper (a) cobb (b) floatation method.
- Determination of tensile index, breaking lens and stretch of paper sample.
- Determination of burst index/ factor and folding endurance of paper sample.
- Determination of tear factor/ index of paper sample.
- Determination of smoothness, softness and porosity of paper sample.
- Determination of brightness, opacity, gloss and pH of paper sample.

5. SECONDARY FIBER TECHNOLOGY

5.1 Secondary Fibers and their sources: Availability of secondary fiber, waste paper supply and demand, Definition and grades, throwouts and prohibitive material, Broad Categories of wastes, Secondary fiber scorce, Storage and handling, waste paper preparation and contaminants removal classification and sorting, coatings, adhesives and printing inks, consumption and use of secondary fiber, Economics of Secondary fiber utilization.

5.2 Processes and Their equipments: Cold process, hot process, dinking processes etc.

5.3 Pulping System: Batch Vs continuous systems, high Vs low consistency pulping stock before cooking, Effect of temperature, pressure, Agitation, Consistency, Chemicals and Process water reuse.

5.4 Washing ink from the pulp slurry: Thickening Vs dilatation washing, Theory of counter current dilution washing, effect of particle size and ink dispersion. low, intermediate and high consistency washes, Economic comparison of washing devices, comparison of washing and froth flotation.

5.5 Flotation Deinking: Fundamental of Flotation, Flotation cell, Flotation deinking process, Measurement of flotation efficiency, Quality of Deinking pulp.

5.6 Cleaning and Screening: Forward cleaners, Forward operating parameters, Control of operating parameter, Lightweight Cleaner, Core Bleed cleaner, pressure screen. Measuring Screen performance, Application of Pressure screen, Controlling pressure screen, Reject Screens, Screening system design conditions.

5.7 Bleaching of Secondary Fiber: Bleaching Deinked newsprint, Bleaching of Chemical pulp, Bleaching of post consumer office waste.

5.8 Effect of recycling on pulp quality, Impact of secondary fiber on paper machine, Water and waste water treatment in recycling mills, Environmental Impact of paper recycling.

5.9 Practical

- Waste paper processing, deinking and evaluation.

1. ADVANCES IN PULPING AND BLEACHING

1.1 High yield chemical pulping methods: Soda/Kraft/pulping with addition of Anthraquinone, oxygen polysulphide, Alkaline peroxide pulping, Alkaline sulphite with or without. Extended delignification, Cold blow techniques. Process modification of batch digestion systems like superbatch, RDH etc and their adaptability in Indian industries. Modification of continuous digestion system.

1.2 Non conventional pulping processes: Organosolv, Explosion and their combinations. Super critical pulping and Easters pulping processes.

1.3 Chemical mechanical, Chemic-thermo-mechanical and semi-chemical pulping. Their comparison in terms of pulp properties and energy consumption.

1.4 Modern bleaching processes with the following agents Chlorine-di-oxide, Oxygen. Ozone, Peroxide per acids, enzyme and chelating agents. Their reactions, process variables, pulp properties, advantages disadvantages & equipments selections.

1.5 Washing equipments: Developments in washings technology, Vacuum drum washers, Pressure washers, Radial Washers, Pressurized diffusers, hi-heat press, wash system, wash press, screw press and belt washer.

1.6 Displacement Bleaching, Water reuse and recycle, Bio-pulping and Bio-bleaching Fundamentals & Economics.

2. ENVIRONMENTAL POLLUTION CONTROL

2.1 Forest Ecosystem and its management: Importance of forests, Forest ecosystem vis-à-vis environment, Man made forest, Social forestry, Forest and Paper Industry

2.2 Air pollution: Contaminants, Industrial Pollutants, odour control. Effects of air pollution and weather, Natural cleansing of pollution and dispersion. Particulate and its Control. Gaseous emission its control, Absorption, Adsorption, Combustion.

2.3 Water Pollution: Explanation of Terms like BOD, COD, Aerobic and Anaerobic condition.

2.4 Pollution Control standard: Treated, untreated, irrigation water.

Problems of Small/Medium paper Mills. Characteristics of effluent from different sections of a mill. Standardization of pulp Mill effluent for Irrigation.

2.5 Effluent Treatment Methods: Primary Treatment, Secondary Treatment (Aerobic and anaerobic, Activated Sludge Process), Tertiary Treatment, In plant Measures to reduce discharges, Zero-effluent concept, Rapson-Reeve process, Solid Waste, Land Pollution, Control methods.

2.6 Practical

- Analysis of effluent and treated effluent for solids, dissolve solids, pH, BOD, COD, dissolve oxygen.