Syllabus

for

ARS Main Examination

(Descriptive Type Questions)

Agricultural Scientists Recruitment Board
Krishi Anusandhan Bhavan, Pusa,
New Delhi – 110 012

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INDEX

01. PLANT GENETICS

Unit 1: General Genetics

Mendelian inheritance. Cell structure and division, Linkage, its detection and estimation. Epistasis. Gene concept, allelism and fine structure of gene. Extra chromosomal inheritance. DNA - structure, function, replication and repair. Genetic code. Gene-enzyme relationship. Transcription and RNA processing. Translation. Gene regulation in prokaryotes and eukaryotes. Genome organization and repetitive DNA. Mobile genetic elements. Chloroplast and mitochondrial genomes. Spontaneous and induced mutations and their molecular mechanisms.

Unit 2: Genome organization and Cytogenetics of Crop Plants

Chromosome structure, function and replication. Recombination and crossing over. Karyotype analysis. Banding techniques. *In situ* hybridization. Special types of chromosomes. Chromosomal interchanges, inversions, duplications and deletions. Polyploids, haploids, aneuploids and their utility. Cytogenetic techniques for gene mapping. Wide hybridization and chromosomal manipulations for alien gene transfer. Genome organization and cytogenetics of important crop species - wheat, maize, rice, Brassica, cotton, Vigna, potato and sugarcane. Construction and use of molecular marker based chromosome maps. Comparative mapping and genome analysis.

Unit 3: Genome Analysis and Cytogenetics of Crop Plants

Principles and procedures of genome analysis. Cytogenetic techniques for gene location and gene transfer, Chromosomal damage-detection and consequences. Pre-and post-fertilization barriers in distant hybridization. Cytogenetics of wheat, maize, rice, Brassicas, cotton tobacco, Vigna sps, sugarcane and potato etc.

Unit 4: Genetic Engineering and Biotechnology

Somatic hybridization, micropropagation, somachonal variation and *in vitro* mutagenesis. Artificial synthesis of gene. Molecular marker aided selection. Vectors. DNA libraries, DNA fingerprinting, DNA sequencing. Nuclei acid hybridization and immunochemical detection. Chromosome walking, RPLP, RAPD and PCR approaches, Recombinant DNA technology, Antisense RNA and ribosomes. Genetic transformation and transgenics.

Unit 5: Quantitative and Biometrical Genetics

Quantitative characters. Multiple factors inheritance. Genetic control of polygenic characters. Heritability, genetic advance and types of selection and correlated response. Mating system and mating design – diallel, line X tester, NC-1, NC-II and NC-III designs, approaches to estimate and exploit component of self and cross pollinated crops. Genotype X environment interaction and stability analysis. Path coefficient, genetic divergence and discriminate function, gene and genotypic frequencies, Hardy Weiuber Law, polymorphism.

02. PLANT BREEDING

Unit 1: Reproductive Systems and Plant Breeding
Crop domestication. Vavilovian laws and Centres of diversity. Early developments in plant breeding. Emergence of scientific plant breeding. Objectives and accomplishments in Plant breeding and the role of National and International institutes. Role of plant introductions in crop improvement. Gametogenesis and fertilization. Modes of sexual and asexual reproduction and its relation to plant breeding methodology. Apomixes, incompatibility and Male sterility systems and their use in plant breeding.

Unit 2: Botanical Classification, Description and Economic Uses of Field Crops
Origin, distribution, classification, description and utilization of economic plants: cereals (wheat, rice, maize, sorghum, pearl millet, minor millets); pulses (pigeonpea, chickpea, black gram, green gram, cowpea, soybean, pea, lentil, horse gram, lab-lab, rice bean, winged bean, lathyrus, French and butter beans, Lima bean); oilseeds (groundnut, sesamum, castor, rapeseed mustard, sunflower, Niger, oil palm, coconut, linseed); fibres and sugar crops, fodder and green manures; medicinal and aromatic plants.

Unit 3: Plant Breeding Methods
Breeding methods for self-pollinated, cross-pollinated and clonally propagated crops. Mass selection and pure line selection. Component and transgressive breeding. Backcrossing. Single seed descent. Multilines. Recurrent selection: intra- and inter population improvement. Development of synthetics and composites. Hybrid breeding and genetic basis of heterosis. Ideotype breeding. Mutation breeding.

Unit 4: Plant Breeding for Stress Resistance and Nutritional Quality
Genetic basis and breeding for resistance to diseases and insect-pests. Breeding for vertical and horizontal resistance to diseases. Genetic and physiological basis of abiotic stress tolerance. Breeding for resistance to heat, frost, flood, drought and soil stresses. Important quality parameters in various crops, their genetic basis and breeding for these traits.

Unit 5: Biometrical and Population Genetics for Crop Improvement
Hardy Weinberg law. Linkage disequilibrium. Genetic load. Polymorphism. Quantitative characters. Multiple factor inheritance, polygenic variation. Breeding value, heritability. Response to selection, correlated response. Estimates of variance components and covariance among relatives. Mating designs with random and inbred parents. Estimation of gene effects and combining ability. Components of variation and their partitioning. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions and stability of performance. Heterosis and its biometrical basis.

Unit 6: Biotechnological Tools for Crop Improvement
Recombinant DNA technology. Plant tissue culture and its application in crop improvement. Genomic and cDNA libraries. DNA sequencing. Recombinant DNA technology. Gene cloning strategies. Genetic transformation and transgenics. Types of molecular markers. Marker based

genetic diversity analysis. Gene tagging, QTL mapping and marker aided selection. Genome projects and utilization of sequence formation.

Unit 7: Plant Genetic Resources and their Regulatory System; Varietal Release and Seed Production

Plant exploration, germplasm introduction, exchange, conservation, evaluation and utilization of plant genetic resources. Convention on Biological Diversity and International Treaty on Plant Genetic Resources for Food and Agriculture. Intellectual Property Rights. Biodiversity Act. Plant Variety Protection and Farmers' Rights Act. System of variety release and notification. Types of seeds and seed chain. Seed production and certification.

Unit 8: Statistical Methods and Field Plot Techniques

Frequency distribution. Measures of central tendency, probability theory and its applications in genetics. Probability distribution and tests of significance. Correlation, linear, partial and multiple regression. Genetic divergence. Multivariate analysis. Design of experiments - basic principles, completely randomized design, randomized block design and split plot design. Complete and incomplete block designs. Augmented design, Grid and honeycomb design. Hill plots, unreplicated evaluation. Data collection and interpretation.

03. ECONOMIC BOTANY

Unit 1 : Plant Taxonomy and Biosystematics

Nomenclature, purpose, principles and systems of classification; Taxonomy of higher plants, floras, manuals, monographs, index, catalogues and dictionaries, herbaria; Concepts of biosystematics, evolution and differentiation of species; Biosystematic and taxonomic tools; Origin, evolution and biosystematics of selected crops (rice, wheat, rape seed & mustard, cotton).

Unit 2 : Economically important plants –I

Origin, history, domestication, botany, genetic resource activities, cultivation, production and use of:
Cereals: Wheat, rice, maize, sorghum, pearl millet and minor millets.
Pulses: Pigeon pea, chickpea, black gram, green gram, cowpea, soyabean, pea, lentil, horsegram, lab-lab bean, ricebean, winged bean, French bean, lima bean, sword bean.
Oilseeds: Groundnut, sesame, castor, rape seed, mustard, sunflower, safflower, niger, oil palm, coconut and linseed.

Unit 3 : Economically important plants –II

Origin, distribution, cultivation, production and utilization of economic plants of following groups such as Fibres: cotton, silk cotton, jute, sunnhemp, agave, flax and mesta (kenoff); Sugars: sugarcane, sugarbeet, sugarpalm and sweet sorghum; Fodders and green manure crops: Plantation crops: coconut, cocoa, tea; root and tuber crops-: potato, sweet potato, tapioca, aroids etc.

Unit 4 : Economically important plants –III

Origin, distribution, classification, production and utilization of Fruits: mango, banana, citrus, guava, grapes and other indigenous fruits; apple, plum, pear, peach, cashewnut and walnut; Vegetables: tomato, brinjal, okra, cucumber, cole crops, gourds etc.; Fumigatories and masticatories: tobacco, betelvine, areacanut; medicinal and aromatic plants: sarpagandha, belladonna, cinchona, nux-vomica, vinca, mentha and glycirrhiza, plantago etc.; Narcotics: cannabis, datura, gloriosa, pyrethrum and opium; Dye-, tannin-, gum- and resin- yielding plants; Plant of agro-forestory importance: multipurpose trees/shrubs, subabool, *Acacia nilotica,* poplar, sesbania, neem etc.; non-traditional economic plants: jojoba, guayule, jatropha, carcus etc.

Unit 5 : Biodiversity and Plant Genetic Resources (PGR)

Biosphere and biodiversity; plant species richness and endemism; concept and importance of plant genetic resources and its increasing erosion; Centres of origin and diversity of crop plants, domestication, evaluation, bioprospecting; National and International organizations associated with PGR; Convention on Biological Diversity (CBD), recent issues related to access and ownership of PGR, IPR,. PBRs, farmers rights, *sui-generis* system etc.

Unit 6 : Germplasm Augmentation
History and importance of germplasm collection, ecogeographical distribution of diversity, logistics of exploration and collection, use of flora and herbaria, random and selective sampling, genepool sampling in self and cross pollinated species; Concept, importance and ecogeographical considerations of introduction and exchange of plant germplasm; prerequisites conventions and achievements of PGR exchange.

Unit 7 : Germplasm Conservation
Principles and methods of conservation, *in situ* and *ex situ* methods, on – farm conservation; Gene banks: short-medium- and long-term conservation strategies; seed physiology and seed technology in conservation; seed storage behaviour (orthodox, recalcitrant), field genebanks, clonal respositories. Gene bank management, gene bank standard for various crops, ISTA, AOSA, IPGRI guidelines, documentation of information in gene bank.

Unit 8 : Biotechnology in PGR
Plant conservation biotechnology, biotechnology in plant germplasm acquisition; plant tissue culture in disease elimination, in vitro conservation and exchange; cryopreservation, transgenics – exchange and biosafety issues; biochemical and molecular approaches to assessing plant diversity.

Unit 9 : Plant Quarantine
Principles, objectives and relevance of plant quarantine; Regulations and plant quarantine set up in Indai; economic significance of seed borne pests, pathogens and weeds; detection and post entry quarantine operations, salvaging of infested/infected germplasm, domestic quarantine.

Unit 10 : Germplasm characterization, evaluation, maintenance and regeneration
Principles and strategies of PGR evaluation, approaches in germplasm characterization and diversity analysis, concept of core collection, descriptors and descriptor states for data scoring; maintenance of working and active collections of self-cross-pollinated and vegetatively propagated crops, perennials and wild relatives; principles and practices of regeneration in relation to mode of reproduction, concept of genetic integrity, genetic shift, genetic drift and optimum environment; post-harvest handling of germplasm; PGR data base management.

04. SEED SCIENCE AND TECHNOLOGY

Unit 1 : Seed Biology

Floral biology, mode of reproduction, sporogenesis, pollination, fertilization, embryogenesis, fruit and seed development. Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Seed structure of monocot and dicot. Seed maturation and longevity in orthodox and recalcitrant seed. Chemical composition of seed. Seed dormancy - types, causes and mechanisms of induction and release, factors affecting, methods to overcome dormancy and its significance in agriculture. Seed germination - requirements, imbibition pattern, physiological and biochemical changes, and role of hormones.

Unit 2 : Seed Production

Introduction to crop breeding methods. Variety testing, release and notification. Genetic purity concept and factors responsible for deterioration of varieties. Maintenance breeding. General system of seed multiplication. Seed production agencies. Identification of seed production areas and factors affecting it. Compact area approach in seed production. Seed production planning, equipment, input and manpower requirement. Factors affecting pollination and seed set viz., temperature, humidity, wind velocity, insect pollinators, and supplementary pollination. Male sterility, self-incompatibility and their role in hybrid seed production. Principles and methods of seed production of varieties and hybrids of cereals like wheat, paddy, sorghum, pearl millet and maize; pulses like chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oilseeds like groundnut, brassica, sesame, sunflower and castor; fibre crops like cotton and jute; vegetables crops like tomato, brinjal, okra, chilli, important cole and cucurbitaceous
crops; important forage legumes and grasses and seed crop management, time of harvesting and threshing/extraction methods. Seed production technology of plantation crops like coffee, tea, rubber, cocoa, cardamom and pepper. Disease free clonal propagation of crops like potato, sugarcane sweet potato, tapioca, colocasia, betel vine, fruit crops like mango, citrus, banana, guava, sapota, pineapple, grape, apple, pear, plum, peach, apricot and seed production and clonal propagation of annual and perennial flowers like rose, gladiolus, chrysanthemum, marigold, dahlia, flox and petunia. Clonal standards and degenerations. Micro propagation.

Unit 3 : Seed Processing

Principles of seed processing. Seed drying principles and methods. Precleaning, grading, treatment, pelleting and packaging. Seed invigoration and enhancement treatment and their applications. Seed processing machines like cleaner cum grader, specific gravity separator, indented cylinder, seed treater, weighing and bagging machines, their operation and maintenance. Seed quality maintenance during processing.

Unit 4: Seed Quality Control

Seed legislation - Seeds Act 1966, Seed Rules 1969 and New Seed Bill 2004, Seed Law Enforcement. Seed certification – history, concept, organization, phases and minimum certification standards. Field inspection principles and methods. Inspection at harvesting, threshing and processing. Pre-and post quality testing or genetic purity. Seed Certification Schemes, concepts and procedures. Seed Testing concepts and objectives, its role in seed quality

control. Seed sampling, seed moisture testing, purity analysis, germination testing, tolerance tests and equipment. Seed testing procedures for principal agri horticultural crops. Quick viability tests. Seed vigour, its significance and testing methods. Testing for genuineness of varieties – principles and methods based on seed, seedling and plant characters, biochemical techniques namely electrophoresis of proteins and isoenzymes and DNA fingerprinting. International Seed Testing Association (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade.

Unit 5 : Seed Storage

Requirements and types of seed storage. Factors affecting seed storage and role of moisture, temperature, RH and moisture equilibrium. Viability nomographs. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Seed drying and Packaging needs. Storage structures. Methods of stacking and their impact. Short and medium term storage. Controlled storage. Germplasm storage. Cryo preservation. Design features of short, medium and long-term seed storage buildings. Operation and management of seed stores.

Unit 6 : Seed Health

Significance of seed health. Mode and mechanism of transmission of microorganisms - fungi, bacteria and viruses. Procedures for seed health test and rules. Externally and internally seed - borne pathogens, mode of infection, development and spread, methods of detection of seed borne diseases. Important seed-borne diseases of cereals, oilseeds, pulses, fibre crops, vegetables and their control measures. Quarantine and International procedures of phytosanitary certificates. Important storage pests, their identification, monitoring and detection. ET value, nature and extent of damage, natural enemies and management. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants.

Unit 7: Seed Industry Development and Marketing

Trends in National and International seed industry development. International Seed Trade Federation (ISF) and Indian seed associations. Economics of seed production. Market survey, demand forecasting, pricing policies, marketing channels, planning and sales promotion. Buyer behavior and role of Government, semi Government, co-operative and private sectors in seed trade. Responsibilities of seed companies and dealers in Seed Act. Seed import and export.

Unit 8 : Protection of Plant Varieties

Plant Variety Protection (PVP) and its significance. Protection of Plant Varieties and Farmers' Right Act, 2001, its essential features. International Union for the Protection of New Varieties of Plants (UPOV) and its role in development of Plant breeders Rights and Seed Industry Development. Impact of PVP on seed supply system. DUS testing principles and application. Biodiversity Act. Criteria for protection of Essentially Derived Varieties (EDVs) and Genetically modified (GM) varieties.

05. PLANT PATHOLOGY

Unit 1: History and Principles of Plant Pathology

Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments of chemicals, legislative, cultural and biological protection measures including classification of plant diseases. Physiologic specialization, Koch's postulates. Growth, reproduction, survival and dispersal of plant pathogens. Factors influencing infection, colonization and development of symptoms.

Unit 2: Laboratory and Analytical Techniques

Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Preservation of microorganisms in pure culture. Methods of inoculation. Measurement of plant disease. Molecular detection of pathogens in seeds and other planting materials: Nucleic acid probes, Southern, Northern and Western hybridization, ELISA, ISEM and PCR. Laboratory equipment and their use: autoclave, hot air oven, laminar flow, spectrophotometer, electrophoresis, light and electron microscopy, incubator, ultracentrifuge, ELISA Reader.

Unit 3: Physiological and Molecular Plant Pathology

Altered metabolism of plants under biotic and abiotic stresses. Molecular mechanisms of pathogenesis: recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance. Phytoalexins. PR proteins. Antiviral proteins. SAR. HR and active oxygen radicals. Tissue culture. Somoclonal variation and somatic hybridization. Elementary genetic engineering. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, hypovirulence cross protection/useful genes and promoter technology biosafety and bioethics.

Unit 4: Mycology

Classification of fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

Unit 5: Plant Bacteriology

Identification and classification of bacteria. morphology, ultrastructure and chemical composition of prokaryotic cell in relation to function. Growth curve, nutrition and auxotrophic mutants. Resting cells in prokaryotic, elementary bacterial genetics and variability: transformation, conjugation, transduction. Biology of extra chromosomal elements: plasmid borne genes and their expression: *avr, her, vie* and *pat* genes. Bacteriophages: lytic and lysogenic cycles. Prokaryotic inhibitors and their mode of action. Economic uses of prokaryotes. Morphology, biochemical characteristics, reproduction and life cycle of phytoplasma and other fastidious prokaryotes.

Unit 6: Plant Virology
Nature, composition and architecture of viruses and viroids. Properties of viruses. Variability in viruses. Satellite viruses and satellite RNA. Assay of plant viruses including biological, physical, chemical, serological and molecular methods. Conventional and biotechnological techniques used in detection and diagnosis. Behaviour of viruses in plants including infection, replication and movement. Histopathological changes induced by viruses in plants, inclusion bodies. Transmission of viruses: virus - vector relationships. Nomenclature and classification of viruses.

Unit 7: Plant Disease Epidemiology
Concepts in epidemiology. Development of disease in plant population. Monocyclic and polycyclic pathogens. Role of environment and meteorological factors in the development of plant disease epidemics. Survey, surveillance (including through remote sensing), and prediction and forecasting of diseases. Epidemic analysis and prediction models. Crop loss assessment: critical and multiple point models.

Unit 8: Phanerogamic parasites and Non-parasitic Diseases
Diseases caused by Phanerogamic parasites and their management. Diseases due to unfavourable soil environment, drought and flooding stress etc. Nutritional deficiencies. Primary /secondary air pollutants and acid rain.

Unit 9: Fungal Diseases of Crop Plants
Fungal diseases of cereals, millets, oilseeds, pulses, fruits, vegetables, plantation, fiber, spices and ornamental crops with special reference to etiology, disease cycle, perpatuation, epidemiology and management. Post harvest diseases in transit and storage; aflatoxins and their integrated management.

Unit 10: Bacterial and Viral Diseases of Crop Plants
Crop diseases of cereals, pulses, oilseeds, vegetables, fruits, plantation and fiber crops caused by bacteria, viruses, viroids, phytoplasmas and other fastidious prokaryotes. Mode of transmission and pathogen vector relationships. Epidemiology and management.

Unit 11: Management of Plant diseases
General principles of plant quarantine. Exotic pathogens and pathogens introduced into India. Sanitary and phytosanitary issues under WTO, TRIPS and PRA. Genetic basis of disease resistance and pathogenicity: gene for gene hyphothesis; parasite mediated frequency -dependent selection concept of QTL mapping; breeding for disease resistance. Production of disease free seeds and planting materials. Seed certification. Chemical nature and classification of fungicides and antibiotics: their bioassy and compatibility with other agricultural chemicals; resistance to fungicides/ antibiotics; effect on environment. Spraying and dusting equipments, their care and maintenances. Important cultural practices and their role in disease management, solarization, integrated disease management. Microorganisms antagonistic to plant pathogens in soil, rhizosphere and phyllosphere and their use in the control of plant diseases; soil fungistasis. Plant growth promoting Rhizobacteria.

06. PLANT NEMATOLOGY

Unit 1: History and Economic Importance

History and economic importance of nematology; Diseases caused by plant-parasitic nematodes-symptomatology, biology, distribution and management of plant parasitic nematodes of economic importance *(Pratylenchus, Radopholus, Hirschmanniella, Meloidogyne, Heterodera, Globodera, Rotylenchulus, Tylenchulus, Ditylenchus, Anguina, Aphelenchoides, Tylenchorhynchus, Helicotylenchus, Hoplolaimus, Scutellonema, Paratylenchus,* etc.). Entomopathogenic nematodes.

Unit 2 : Nematode Taxonomy and Morphology

Principles and concepts of taxonomy. Rules of nomenclature. Nematode phylogeny and systematics. Classification of soil and plant -parasitic nematodes and their relationships with other related phyla. Detailed classification of plant - parasitic nematodes up to generic level with emphasis on genera of economic importance. General morphology and anatomy of nematodes. Various systems: digestive,, excretory, nervous, reproductive etc., developmental biology of nematodes.

Unit 3 : Nematological Techniques

Methods of extraction of nematodes from soil and plant material. Microscopy - principles and types including electron microscopes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Techniques for histopathology and culturing of nematodes - plant parasitic, entomophilic and saprophytic including axenic methods. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide screening, screening and evaluation for nematode resistance in crops. Molecular technique for nematode diagnostics. Techniques for mass culturing of nematode antagonistic bioagents.

Unit 4 : Nematode Ecology

Ecological classification and distribution of nematodes. Mode of nematode dispersal. Adaptations to parasite mode of life. Soil as environment for nematodes. Effect of biotic and abiotic factors on nematode survival, activity and reproduction. Nematode population dynamics. Nematode -induced plant damage and modeling. Community analysis.

Unit 5 : Plant Nematode Relationships

Types of parasitism in nematodes. Nature of damage caused by various groups of plant parasitic nematodes and mechanisms involved. Pathotypes in nematodes. Mechanism of nematode resistance and tolerance in plants and its assessment. Physiological, biochemical and molecular changes in plants due to nematode infections.

Unit 6 : Nematode Physiology and Cytology

Chemical composition of nematodes. Principles of nematode physiology. Physiological functions of cell; organelles. Physiology of respiration, digestion, excretion, reproduction, growth and development. Physiology of muscular, nervous and sensory responses. Physiology of moulting, hatching and nematode survival. Chemoreception in nematodes. Nematode as biological models - Caenorhabditis elegans. Cytological changes in plants due to infection including syncytia, giant cell formation and their modification etc.

Unit 7 : Nematode Management

Principles and methods of nematode management - physical, cultural biological, chemical and legislative, Nematicides (including those of biological origin) - history, classification, formulations, application and mode of action. Host resistance for nematode management. Integrated nematode management. Role of biotechnology in nematode management.

Unit 8 : Interactions of Nematodes with Soil Organisms

Importance of interactions (interrelationships) of nematodes with soil organisms. Interactions of nematodes with bacteria, fungi, viruses, mycorhizae and other nematodes. Nematodes as vectors of viruses and other microorganisms.

Unit 9 : Statistics

Frequency distribution. Measures of central tendency and dispersion: mean, median, mode, standard deviation etc. Population distributions : normal, binomial and poisson. Correlations: partial and multiple. Tests of significance: t, F and Chi square and randomized block, Latin square and split plot designs, their analysis and interpretation.

07. AGRICULTURAL ENTOMOLOGY

Unit 1: Systematics
History and development of Entomology, Evolution of insects, position of insects in the animal world, characteristics of phylum Arthropoda, structural features of important arthropod groups such as Trilobita, Chelicerata and Mandibulata, structural features of important classes of phylum Arthropoda viz. Arachnida, Crustacea, Chilopoda, Diplopoda and Hexapoda. Classification of insects up to order level, habits, habitats and distinguishing features of different Order and important Families.

Unit 2: Morphology
Body wall, its structure, outgrowths, endoskeleton, Body regions, segmentation, sclerites and sutures. Head and head appendages, types of mouth parts, antennae, their structure and types. Thorax structure, thoracic appendages and their modification. Wings, their modification and venation, Abdomen; structure, abdominal appendages both in Pterygota and Apterygota. External genitalia, general structure and modification in important insect orders.

Unit 3: Embryology, Internal Anatomy and Physiology
Embryonic and post embryonic development, types of metamorphosis, physiology of ecdysis. General features and types of larvae and pupae. Structure, function and physiology of Digestive, Circulatory, Respiratory, Reproductive, Nervous and Excretory systems, Sense Organs; structure and types. Insect food and nutrition; minerals, carbohydrates, proteins and amino acids, lipids, vitamins and their role in growth and development, artificial diets.

Unit 4: Ecology
Concept of ecology, Environment and its components-biotic and abiotic factors and their effects on growth, development, population dynamics, distribution and dispersal. Principle of biogeography and insects biodiversity. Biotic potential and environmental resistance. Ecosystems, agroecosystems analysis, their characteristics and functioning. Intra and inter specific relationship; competition, predator-prey and host-parasite interactions, ecological niche. Life table studies, population models. Food chain and food web. Arthropod population monitoring, pest forecasting. Diapause and causes of pest out breaks.

Unit 5: Biological Control
Importance and scope of biological control, history of biological control: Biocontrol agents-parasites, predators and insect pathogens. Important entomophagous insect Orders and Families. Ecological, biological, taxonomic, legal and economic aspects of biological control, phenomena of multiple parasitism, hyperparasitism, superparasitism and their applied importance. Principles and procedures of using exotic biocontrol agents. Utilization of natural biocontrol agents: conservation, habitat management and augmentation. Mass multiplication techniques and economics. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests.

Entomophilic pathogens: bacterial, fungi, viruses, rickettsiae, Protozoan and nematodes, Modes of transmission, methods of uses, symptoms of infection. Microbial insecticides and their

formulation. Merits and demerits of microbial control. Role of biocontrol agents and microbial insecticides in Integrated Pest Management.

Unit 6: Chemical Control and Toxicology

History, scope and principles of chemical control. Insecticides and their classification. Formulations of insecticides. Susceptibility of insects to the entry of insecticides. Physical, chemical and toxicological properties of different groups of insecticides: chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, chlordimeform, chitin synthesis inhibitors, avermectins, nitroguandines, phenylpyrrozzoles, botanicals (natural pyrethroids, rotenone, neem products, nicotine, pongamia spp. etc). Combination insecticides. Problems of pesticide hazards and environmental pollution. Safe use of pesticides, precautions and first aid treatments. Insecticides Act 1968, registration and quality control of insecticides.
Evaluation of toxicity, methods of toxicity testing, determination of LD_{50}, LT_{50}, RL_{50} etc. Pesticides residues in the environment and their dynamics of movements, methods of residue. Pharmacology of insect poisons. Mode of action of different groups of insecticides; neuroactive (axonal and synaptic) poisons, respiratory poisons, chitin synthesis inhibitors. Metabolism of insecticides; activative and degradative metabolism, detoxification enzymes and their role in metabolism. Selectivity of insecticidal actions; insecticide resistance; mechanism, genetics and management of insecticide resistance.

Unit 7: Host Plant Resistance

Chemical ecology: mechano and chemo receptors. Host plant selection by phytophagous insects. Secondary plant substances and their defenses against phytophagous insect. Basis of resistance (Antixenosis, Antobiosis, Tolerance). Biotypes development and its remedial measures. Tritrophic interactions, induced resistance. Breeding for insect resistant plant varieties. Resistance development and evaluation techniques. Genetics of Resistance: vertical resistance, horizontal resistance, oligogenic resistance, polygenic resistance. Biotechnological approaches and development of transgenic insect resistant plants, its advantages and limitations. Case histories. Insect resistance to transgenic plants and its management.

Unit 8: Innovative Approaches in Pest Control

Behavioral control: pheromones-types and uses, advantages and limitations. Hormonal control: types and function of insect hormones, insect hormone mimics, advantages and limitations. chemosterilants, antifeedants, attractants, repellents; their types, method of applications, advantages and limitations. Genetic control: concepts and methods, case histories, advantages and limitations. Potentialities of IPM.

Unit 9: Integrated Pest Management

History, concept and principles of IPM. Components of IPM: Host plant resistance, agronomic manipulations, mechanical and physical methods, chemical methods, biocontrol agents utilization, genetic and behavioral control strategy etc. IPM strategies for field and horticultural crops. IPM case histories. Concept of damage levels- Economic threshold levels (ETL), Economic injury levels (EIL) and their determination. System approach, Agro ecosystem and cropping system *vs.* IPM. Constraints and Strategies of IPM implementation.

Unit 10: Pesticide Application Equipments
Types of appliances: sprayers, dusters, fog generators, smoke generators, soil injecting guns, seed treating drums, flame throwers, etc. Power operated sprayers and dusters. Types of nozzles and their uses. Maintenance of appliances. Aerial application of pesticides, principles of aerial application, factors affecting the effectiveness of aerial application. Equipments for aerial applications. Advantages and disadvantages of aerial application.

Unit 11: Pests of Field Crops and their Management
Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of cereals, Oilseed, pulses and fibre crops, sugarcane and tobacco. Polyphagous pests: locusts, termites, hairy catepillars, cut worms and white grubs.

Unit 12: Pests of Horticultural Crops and their Management
Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of vegetables, fruits and plantation crops, spices, condiments and ornamentals.

Unit 13: Pests of Stored Products and their Management
Fundamentals of storage of grains and grain products. Storage losses, sources of infestation/infection, factors influencing losses, insect and non-insect pests, their nature of damage and control. Microflora in storage environment and their control. Storage structures, bulk storage and bag storage, their relative efficacy and demerits. Grain drying methods and aeration. Non-insect pests (rodents, birds, mites) of stored products and their control. Integrated management of storage pests.

Unit 14: Arthrpod Vectors of Plant Diseases
Common arthropod vectors *viz*., aphids, leaf hoppers, plant hoppers, whiteflies, thrips, psylids, beetles, weevils, flies, bees and mites and their relationship with the plant pathogenic fungi, bacteria, viruses, mycoplasma. Mechanism of pathogen transmission : Active mechanical transmission, biological transmission. Toxicogenic insects, mites and phytotoxemia. Some important arthropod vector transmitted diseases and their epidemiology in India. Management of vector and its effect on control of diseases.

Unit 15: Honey Bees and Bee-keeping
Honey bees and their economic importance. Bee species, their behaviour, habit and habitats. Bee Keeping: bee pasturage, hives and equipments, seasonal management. Bee enemies including diseases and their control.

Unit 16: Silkworms and Sericulture
Silkworm species, their systematic position and salient features. Rearing techniques of mulberry-muga-eri and tassar silkworms. Nutritional requirements of silkworms. Sericulture: rearing house and appliances, silkworm breeds, principles of voltism and nioultism, seed production and its economics. Enemies and diseases of silkworms and their management. Sericulture organization in India.

Unit 17: Lac Insect
Lac insect, its biology, habit and habitats. Host Trees: pruning, inoculation, lac cropping techniques, and harvesting. Enemies of lac insect and their control.

Unit 18: Other Useful Insects
Pollinators, biocontrol agents of weeds, soil fertility improving agents, scavengers. Use of insects and insect products in medicines. Usefulness of insects in scientific investigations, insects as food.

Unit 19: Statistics and Computer Application
Frequency distribution, mean, mode and median. Standard, normal, bionomial and Poisson's distribution, Sampling methods and standard errors. Correlation and regression: Partial and multiple, tests of significance; t, F, chi- square, Duncan's multiple range tests. Design of experiments: Principles of Randomized block design, Completely r
andomized block design, Latin square design, Split-plot designs. Probit analysis. Use of soft ware packages like SPSS, SAS, etc. for the above tests and designs of experiments for analysis.

08. AGRICULTURAL CHEMICALS/ ORGANIC CHEMISTRY

Unit 1 : General Chemistry

Atomic structure and electronic configuration, nature and type of chemical bonding, surface phenomenon (including colloids), radioactivity, laws of thermodynamics, osmosis and osmotic pressure, elemental analysis for molecular structure determination, organic functional groups, stereochemistry and chirality, mechanisms of chemical reactions (displacement, elimination, addition, rearrangement), reaction involving free radicals, benezene and carbene intermediates, tautomerism.

Unit 2 : Organic Reaction Mechanisms

Beckmann, Claisen, Fries and Wagner Meerwein rearrangements. Claissen condensation. Dickmann, Curlius, Friedal Crafts, Michael, Perkin Kolbes, Hoffman, dieds Alder, Arndt-Eistert and Witting reactions. Aldol condensation, Benzilic acid and Benzidin rearrangements, Grignard reagents.

Reagents in organic synthesis in relation to stability of final product and steric approach control. Polymers and polymerization reactions.

Unit 3 : Analytical Chemistry

Volumetric and gravimetric analysis, theory of indicators, Emission and absorption spectroscopy, basic principles and application of spectrophotometry. IR, NMR and mass spectrometric techniques. Principles and practices in radiotracer analysis. Principles, types and applications of chromatography; column, paper, thin layer, ion exchange, gas liquid and high performance liquid.

Unit 4: Chemistry of Natural Products

Carbohydrates, amino sugars, glycosides, cellulose and starch, saponins and sapogenins, proteins, amino acids, enzymes, nucleic acids, vitamins, lipids, essential oils and polymers. Chemistry of alkaloids, phenolics, isoprenoids and plant pigments, juvenile hormones.

Sources, isolation, characterization, properties and mode of action of important groups of naturally occurring insecticides: pyrothroids, niconoids, retonoids, limonoids and microbial macrolides (avermectins and milbemycins), semio chemicals, insect hormones, insect growth regulators. Allelochemicals, plant hormones, phytoallaxins. Humus, its formation, composition and properties.

Unit 5 : Chemistry of Synthetic Pesticides

Chemistry of major groups of insecticides (organo-chlorine, organo-phosphorus. organo-carbamatcs, synthetic pyrethroids etc.), fungicides (dithiocarbamates, phenols, quinines, carboxamides, azoles etc.), herbicides (phenoxyacids. Carbamates, amides, triazines, penylureas, dinitroanilines, bipyridiliums etc.), rodenticides (coumarins etc), acaricides and basic concepts in pesticide formulation.

Unit 6 : Chemistry of Plant Production Chemicals

Essential plant nutrients (major, secondary and micro), organic manures (farm yard, compost, sewage sludge, green manure, biogas slurries, etc.), production and manufacture and uses of various nitrogenous, phosphatic, potassic and complex fertilizers and fertilizer mixtures, liquid fertilizers, biofertilizers, integrated plant nutrient systems. Nutrient use efficiency (principles and approaches). Soil conditioners and amendments.

Unit 7 : Environmental Implications of Agrochemicals

Chemodynamics of agrochemicals (pesticides, fertilizers etc.) in agroecosystems, biotic and abiotic transformations, principles of monitoring and analysis, toxicological aspects. Heavy metal pollution. Effects on non-target organisms. Agrochemical disposal / destruction: approaches and implications. Industrial effluents (nature, treatment, disposal). Other related chemical xenohiotics. Key provisions of the Insecticides Act (1968), The Fertilizer Control Order (1985). The Water (Prevention and Control of Pollution) Act (1974). Air (Prevention and Control of Pollution) Act (1981) and the Environmental Protection Act (1986).

09. BIO-CHEMISTRY (PLANT SCIENCE)

Unit 1: Basic Biochemistry and Biomolecules

Scope and importance of biochemistry and molecular biology in plants. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriophages, cell organelles function and their fractionation. Chemical bonding in biological systems, pH and buffers. Thermodynamics and bioenergetics- concept of entropy, and free energy changes in biological reactions, Redox reactions, Role of high energy phosphates. Biomembranes. Classification structure, chemistry, properties and function of carbohydrates, proteins, lipids and nucleic acids. Components of immune system, Prostaglandins.

Unit 2: Intermediary Metabolism

Anabolism, catabolism and their regulation. Metabolism of carbohydrates – glycolitic pathway, HMP pathway, TCA cycle, glyoxylate pathway and gluconeogenesis. Biological oxidation-electron transfer and oxidative phosphorylation. Lipid metabolism, degradation and biosynthesis of fatty acids, ketogenesis and causes of ketosis. Biosynthesis of sterols and phospholipids. Amino acid metabolism – catabolism of amino acids, transamination and deamination, urea cycle, biosyntheisis of amino acids. Conversion of amino acids into bioactive compounds. Metabolism of nucleic acids-degradation and biosynthesis of purines, pyrimidines and nucleotides. Integration of carbohydrate, lipid and amino acid metabolism. Signal transduction mechanisms. Role of G-proteins, cyclic nucleotides and calcium in transduction. Disorders of lipid, carbohydrate, nucleic acid, amino acid metabolism. Inborn errors of metabolism. Secondary metabolites, biotransfermation and over expression.

Unit 3: Enzymes, Vitamins and Hormones

Major classes of enzymes, general properties, kinetics, active site and its mapping, activation energy and transition state. Mechanisms of enzyme action, inhibition and activation. Coenzymes and cofactors. Isoenzymes and immobilized enzymes. Regulation of enzyme activity, allosteric regulation. Multi substrate reactions, kinetic experiments to determine the mechanism of multi substrate reactions. Isolation, purification and measurement of enzyme activity. Enzyme units. Enzyme engineering. Role of enzymes in agriculture, industry, and medicine. Structure, mode of action and metabolic functions of vitamins. Deficiency diseases associated with vitamins. General description of nature hormones and disorders associated with endocrine glands, viz. pituitary, thyroid, adrenal, pancreas and gonads. Peptide and steroid hormones. Phyto hormones – auxins, gibberellins, cytokinins, ethylene, abscisic acid and new plant bio-regulators like SA, Brassino of .

Unit 4: Molecular Biology

Structure of DNA and RNA Replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression - operon model, induction and repression, control of gene expression in prokaryotes and eykaryotes. Chloroplant and Mitochondrial genomes. Replication of viruses. Mutagens, oncogenes and carcinogenesis. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, DNA and protein sequence analysis,

oligonucleotide synthesis, genomic and cDNA library construction, site-directed mutagenesis, transposon tagging, chromosome walking. Basics of genome organization and mapping, functional genomics. Gene silencing. Methods for the development of transgenic organisms. Computer application in molecular biology, primer designing, sequence analysis and phylogenetic analysis. Benefits of gene manipulation in agriculture, nanobiotechnology, bio-chips.

Unit 5: Techniques in Biochemistry

Principles of optical, phase contrast, fluorescence and electron microscopy, spectrophotometry, UV and VIS, fluorimetry, turbidometry and atomic absorption spectrophotometry. Radioisotopic techniques – scintillation counters and autoradiography and their application in biological sciences. Flectrophoresis - general principles and application, gel electrophoresis, isoelectric focusing, pulsed field gel electrophoresis, immunoelectrophoresis. Chromatographic techniques - paper, thin layer, column chromatography, GC and HPLC. Centrifugation - principles of sedimentation in various rotors, differential centrifugation, density gradient centrifugation and ultracentrifugation. Cell tissue and organ culture. Cryopreservation, PCR and application of RFLP, RAPD, AFLP, microsatellite and mitochondrial and ribotyping techniques. Southern, Northern and Western blotting, ELISA. Microarray and DNA chips. Preliminary methods of statistical analysis as applied to agricultural data – standard deviation, standard error, ANOVA, correlation and regression.

Unit 6: Biochemistry of Food-grains, Fruits and Vegetables

Fundamentals of nutrition, concept of balanced diet. Nutritional quality of protein and its evaluation. Dietary fibre. Vitamins- biochemical functions and deficiency diseases. Fats and lipids-types of fatty acids and their significance in health. Biochemical composition and food value of various food grains (including cereals, pulses, oil seeds), fruits and vegetables. Biochemistry of fruit ripening, biochemical aspects of post harvest technology, storage and preservation. Biochemical basis of quality improvement of food grains, vegetables and fruits. Antioxidants, nutraceticals. Food toxins and anti-metabolites, food additives, storage proteins.

Unit 7: Photosynthesis

Photosynthesis – photosynthetic pigments, light reactions, photosystems. Photophosphorylation, dark reactions: C3, C4 and CAM pathways. Regulation of Rubisco. Chemisomotic coupling. Carbon cycle and its regulation, Ion fluxes and conformational changes during photosynthesis. Photorespiration. Relationship between photosynthesis, photorespiration and crop productivity. Chloroplasm morphology, structure and biochemical anatomy. Cytosolic and organelle interactions. Nature and exchange of metabolites through translocators. Seed reserve biosynthesis.

Unit 8: Plant Metabolic Processes

Uptake and metabolism of mineral nutrients in plants. Sulphur metabolism. Nitrogen cycle, nitrate and nitrite reduction, denitrification, symbiotic and non-symbiotic nitrogen fixation. Biochemical and physiological role of hydrogenase. Chemoautrotrophy in rhizobia and nitrifying bacteria. Cell cycle. Growth regulation in plants. Signal transduction and phytohormones. Molecular mechanisms of plant growth, hormone action. Role of oligosaccharides and

polysaccharides in cellular metabolism. Metabolism of cyanogenic glycosides and glucosinolates.

Unit 9: Plant Molecular Biology

General organization of nuclear, mitochondrial and chloroplast genomes. Genomics and functional genomics. Tissue specific expression of genes. Molecular biology of various stresses – drought, salinity and temperature. Signal transduction and its molecular basis: molecular mechanism of plant hormone action. Structure, organization and regulation of nuclear genes. Genes involved in photosynthesis and nitrogen fixation. Regulation of chloroplast gene expression. Mitochondrial control of fertility. Molecular markers in plants and their uses.

Unit 10: Plant Biotechnology / Genetic Engineering

Totipotency, application of tissue culture for plant improvement, cryopreservation. Protoplasm fusion. General principles of gene cloning. Isolation and characterization of plant genes and promoters. Different methods of gene transfer –direct and vectormediated. Gene silencing. Site directed mutagenesis. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement – insect-pest resistance (insect, viral, fungal and bacterial diseases). Abiotic stress tolerance, herbicide resistance, storage protein quality improvement, increasing shelf- life, oil quality. Biosafety and IPR issues.

10. PLANT PHYSIOLOGY

Unit 1: Cell Organelles and Water Relations

Cell organelles and their physiological functions Structure and physiological functions of cell wall, cell inclusions. Cell membrane structure and functions. Water and its role in plants, properties and functions of water in the cell, water relations, water potential of plant cells. Mechanism of water uptake by roots transport in roots, movement of water in plants, water loss from plants, energy balance, solar energy, input energy dissipation at crop canopy level. Evapotranspiration, plant factors influencing transpiration rate. Stomata, structure function - Mechanism of stomatal movement, antitranspirants. Physiology of water high temperature and salinity stress in plants. Influence of water stresses at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

Unit 2: Metabolic Processes and growth Regulation

Energy and work, free energy and chemical potential, redox reactions and electrochemical potential. Enzyme classification and mechanism of action, factors affecting enzyme action. Gene expression and protein turnover. Photosynthesis, translocation and respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis and bioproductivity. Photochemical process- Chloroplast, its structure, CAM plants and their significance. Rubisco structure and regulations, Photorespiration and its significance, CO_2 fixation as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides. Translocations of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism. Inorganic nitrogen species (N_2, $N0_3$, NH_3) and their reduction, protein synthesis, nucleic acids. Sulphate uptake and reduction. Lipid metabolism-storage, protective and structural lipids. Secondary metabolites and their significance in plant defence mechanism. Growth and differentiation, hormonal concept of growth and differentiation, plant growth hormones (auxins, gibberellins, cyctokinins, ABA, ethylene etc.), biosynthesis of growth hormones and their metabolism, synthetic growth regulators, growth retardant, apical dominance, senescence, fruit growth, abscission, photo-morphogenesis, photo-receptors, phytochrome, physiology of flowering, photoperiodism and vernalisation.

Unit 3: Crop Productivity and Modeling

Role of crop physiology in agriculture, crop growth and productivity, crop growth models describing yield (Duncan/Passioura), phenology-crop productivity, growth factors related to biomass - concept of growth rates- canopy photosynthesis (leaf area and net assimilation rates as determining factors). Light interception as a major function of leaf area-index, LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, yield and yield structure analysis. Concept of source and sink, factors influencing source and sink size and productivity. Environmental factors determining crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages. Ideotype concept-selection- indices for improving crop productivity.

Unit 4: Abiotic Stress Responses in Plants

Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, interactions between biotic and abiotic stresses. Drought characteristic features, water potential in the soil-plant-air continuum. Development of water deficits, energy balance concept, transpiration and it's regulation – stomatal functions/VPD. Physiological process affected by drought. Drought resistance mechanisms: Escape, dehydration postponement (Drought avoidance), Dehydration tolerance, and characteristics of resurrection plants. Osmotic adjustment Osmoprotectants, stress proteins. Water use efficiency as a drought resistance trait. Molecular responses to water deficit stress perception, expression of regulatory and function genes and significance of gene products. Stress and hormones-ABA as a signaling molecule – Cytokinin as negative signal. Oxidative stress: reactive oxygen species (ROS) – role of scavenging systems (SOD, catalase etc.). High temperature stress: tolerance mechanisms- role of membrane lipids in high temperance tolerance. Functions of HSPs chilling stress; effects on physiological processes. Crucial role of membrane lipids. Salinity: species variation in salt tolerance. Salinity effects at cellular and whole plant level, tolerance mechanisms. Breeding for salt resistance. Heavy metal stress: aluminum and cadmium toxicity in acid soils. Role of phytochelatins (heavy, metal binding proteins).

Unit 5: Plant Growth Regulators and Plant Development

Plant growth regulators – Hormones, endogenous growth substances and synthetic chemicals. Endogenous growth regulating substances other than hormones. Brassinosteriods, triacontanol, phenols polyamines, jasmonates, concept of death hormone. Classification, site of synthesis, biosynthetic pathways and metabolism and influence on plant growth and development by auxins, gibberellins, cytokinins, abscisic acid and ethylene. Concept of hormone action - hormone receptors and signal transduction Hormone mutants. Hormonal regulation of gene expressions at various developmental stages of plant-flowering, seed maturity, seed dormancy. Action of hormones on cellular functions: Auxins- cell elongation, retardation of abscission of plant parts, gibberellins – stem elongation, germination of dormant seeds, cytokinins- cell division, retardation of senescence. Abscisic acid- stomatal closure and induction of drought resistance, ethylene- fruit ripening, acceleration of senescence of leaves. Interaction of hormones in regulation of plant growth and development processes. Synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission. Growth and differentiation, hormonal concept of growth and differentiations. Rooting of cuttings- flowering- physiological and molecular aspects of control of reproductive growth. Apical dominance, senescence and abscission. Fruit growth and development, physiological and molecular aspects of ripening processes and improving post harvest life of fruits. Induction and breaking dormancy in seeds and buds. Synthetic growth regulators. Practical utility in agriculture and horticulture. Herbicides, classification and their mode of action.

Unit 6: Mineral Nutrition

Importance of mineral nutrition in plant growth. Classification and essentiality criteria. General mechanisms - concept of apparent free space and nature of bio-membranes. Dual mechanism and other concepts of ion uptake. Short distance transport-pathway from external solution (Apoplasm) to sieve across the root cortical cells-factors contributing to xylem loading. Long distance transport in xylem and phloem, xylem unloading in leaf cells. Uptake and release of mineral nutrients by foliage. Rhizosphere and root biology, root growth, influence of micro-

organism in nutrient acquisition, release and uptake by plant roots. Yield and mineral nutrition- concept of nutrient use efficiency, Mineral nutrition under adverse soil situations- drought, salinity, acidity etc. Heavy metal toxicity and concept of phytoremediation. Interaction of phytohormones and nutrients. Molecular aspects- uptake and transport, role of transporter genes, genetics of nutrient uptake, identification and transfer of genes for tolerance to nutrient deficiencies, etc.

Unit 7: Climate and Climate Change

Climate- Analytical methods to determine long term changes in environment- Tree ring, cellulose, stable carbon isotope discrimination, stable ^{18}O discrimination for hydrological changes. Likely changes in climate in future and its impact on crop and ecosystems. The greenhouse gases and global warning. CO_2 as an important greenhouses gas, global carbon deposits, fluxes in the sinks and sources. Approaches to contain atmospheric CO_2 level. Effect of elevated CO_2 on plant growth and development. Methane as a greenhouse gas. Prediction on global warming, GCA models, effects on climate and biota. High temperature and CO_2 interaction on plant growth and productivity, ionising radiation UV-B chlorofluro carbon (CFC)– their impact on ozone layer- ozone hole and alteration in UV-B radiation. Effects of UV-B radiation on plant ecosystem, repair and acclimation to UV-B damage. Carotenoids and their role in membrane stabilization. Air pollution, SO_2, NO, methane, ozone, peroxy acetyl nitrate and their effect on ecosystem. Industrial and domestic effluent- their effect, on aquatic ecosystem, plant growth and development.

Unit 8: Seed Physiology

Structure of seeds and their storage. Seed development patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Storage of carbohydrates, proteins and fats in seeds. Hydration of seeds. Physiological processes. Seed respiration, mitochondrial activity Mobilization of stored resource in seeds. Chemistry of oxidation of starch, proteins and fats. Utilization of breakdown products by embryonic axis. Control processes in mobilization of stored reserves. Role of embryonic axes. Gibberellin and α-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, role of LEA proteins. Seed viability. Seed dormancy. Means to overcome seed dormancy.

Unit 9: Physiology of Flowering and Reproduction

Evolutionary history of flowering plants (angiosperms). Semelparous and iteroparous reproduction, monocarpic and perennial life etc. Flowering phenomenon, effect of plant age, juvenility- transition to flowering. Flowering nature and classification of plants. Photoperiodic responses and the mechanisms in short and long day plants. Theories related to flowering. Endogenous substances and flowering. Gene expression in flowering. Control of flowering. Thermoperiodism - photo and thermo-period interactions.Vernalization-mechanism. Photomorphogenesis, photoreceptors, phytochrome, cryptochrome, physiology of flowering, photoperiodism and vernalization. Optimization in flowering response-to environmental features (light, temperature, stress) etc. plant reproductive physiology. Mating strategy in plants, molecular techniques to understand mating patterns, self-incompatibility responses, physiological processes mediating fertilization (pollen-stigma interactions), seed and fruit development, seed and fruit abortion and means to overcome it. Molecular biology of seed

development, physiological basis of cytoplasmic male sterility and fertility restoration. Physiology of heterosis.

Unit 10: Physiology of Horticultural and Plantation Crop species

Growth and development of horticultural and plantation crop species. Juvenility, shoot growth, types of shoots, patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing. Growth measurements. Water relations of tree species. Water uptake and transport. Concepts of transpiration rate and water use efficiency. Sexual and asexual propagation. Rootstock and scion interactions. Physiology of flowering in perennial species, photoperiodism and thermoperiodism. Physiological aspects of fruit crops: mango, banana, grapes, citrus, papaya and pineapple etc. Physiological aspects of plantation crops: tea, coffee, cardamom, coconut, and blackpepper.

Unit 11: Post-Harvest Physiology

Senescence and ageing in plants. Ethylene – the senescence hormone, leaf senescence. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence. Gene expression during senescence. Concept of physiological maturity of seeds - post harvest changes in biochemical constituents in field crops - loss of viability, loss of nutritive value, environmental factors influencing post-harvest deterioration of seeds. Physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest life of cut flowers. Physical, physiological and chemical control of post - harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport. Molecular approach in regulation of fruit ripening. Transgenic technology for improvement of shelf-life. Edible vaccine

Unit 12: Morphogenesis, Tissue Culture and Plant Transformation

Morphogenesis; the cellular basis of growth and morphogenesis; polarity in tip growing cells and diffusive growing cells. Control of cell division and differentiation, phyto-chromes, different forms, physiological effects and gene regulation, and cellular totipotency, physiology and biochemistry of differentiation, in organ cell, tissue and cultures, micropropagation strategies, application of tissue culture in agriculture, horticulture, forestry and industry: plant transformation; transformation vectors, concept of selectable and scorable markers. *Agrobacterium* mediated transformation, binary vectors, biolistics. Electroporation, selection of putative transgenic plants, genetic analysis. PCR, Southern analysis evaluation of transgenic plants.

11. AGRICULTURAL BIOTECHNOLOGY

Unit 1: Cell Structure and Function
Prokaryotic and eukaryotic cell architecture, Cell wall, plasma membrane, Structure and function of cell organelles: vacuoles, mitochondria, plastids, golgi apparatus, ER, peroxisomes, glyoxisomes. Cell division, regulation of cell cycle, Protein secretion and targeting, Cell division, growth and differentiation.

Unit 2: Biomolecules and Metabolism
Structure and function of carbohydrates, lipids, proteins and nucleic acids, Synthesis of carbohydrate, glycolysis, HMP, Citric acid cycle and metabolic regulation, Oxidative phosphorylation and substrate level phosphorylation, Vitamins, plant and animal hormones. Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds.

Unit 3: Enzymology
Enzymes, structure conformation, classification, assay, isolation, purification and characterization, catariysis specificity, mechanism of action, active site, regulation of enzyme activity, multienzyme complexes, immobilized enzymes and protein engineering, immobilized enzymes and their application.

Unit 4: Molecular Genetics
Concept of gene, Prokaryotes as genetic system, Prokaryotic and eukaryotic chromosomes, methods of gene isolation and identification, Split genes, overlapping genes and pseudo genes, Organization of prokaryotic and eukaryotic genes and genomes including operan, exon, intron, enhancer promoter sequences and other regulatory elements. Mutation – spontaneous, induced and site-directed, recombination in bacteria, fungi and viruses, transformation, transduction, conjugation, transposable elements and transposition.

Unit 5: Gene Expression
Expression of genetic information, operon concept, Transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, activators, repressors, co-activators, Co-repressors in prokaryotes and eukaryotes, inducible genes and promoters, Transcription factors post transcriptional modification and protein transport, DNA-protein interaction, Genetic code. Mechanism of translation and its control, post translational modifications.

Unit 6: Molecular Biology Techniques
Isolation and purification of nucleic acids. Nucleic acids hybridization: Southern, northern and western blotting hybridization. Immune response monoclonal and polyclonal antibodies and ELISA, DNA sequencing. Construction and screening of genomic and C-DNA libraries. Gel electrophoretic techniques. Polymerase chain reactor spectroscopy, rtPCR ultracentrifugation, chromatography, FISH, RIA etc.

Unit 7: Gene Cloning
Restriction enzymes and their uses. Salient features and uses of most commonly used vectors i.e. plasmids, bacteriophages, phagmids, cosmids, BACs, PACs and YACs, binary vectors, expression vectors. Gene cloning and sub-cloning strategies, chromosome walking, genetic transformation, Basis of animal cloning. Biology. Risk assessment and IPR.

Unit 8: Molecular Biology
Ribosome structure and function. Protein biosynthesis in prokaryotes and ekaryotes. Post-translational modification. Gene regulation, RNA processing and Post transcriptional modifications. Bioprospecting, biofortification, gene pryrimiding and gene fusion, nbozyme technology.

Unit 9: Plant Molecular Biology
Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular mechanism of nitrogen fixation. Molecular biology of various stresses, *viz.* abiotic stresses like drought, salt, heavy metals and temperature; and biotic stresses like bacterial, fungal and viral diseases. Signal transduction and its molecular basis, molecular mechanism of plant hormone action mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis.

Unit 10: Tissue Culture
Basic techniques in cell culture and somatic cell genetics. Regulation of cell cycle and cell division.. Clonal propagation. Concept of cellular totipotency. Anther culture, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. *In vitro*, mutagenesis, cryopreservation and plant tissue culture repository.

Unit 11: Plant Genetic Engineering
Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Different methods of gene transfer to plants, *viz.* direct and vector-mediated. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement, i.e. insect-pest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, Current status of transgenics, biosafty norms and controlled field trials and release of transgenics (GMOs).

Unit 12: Molecular Markers and Genomics
DNA molecular markers: Principles, type and applications; restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP), randomly amplified polymorphic DNA sequences (RAPD), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), Structural and functional genomics, gene mapping, genome mapping, gene tagging and comparative genomics and application of genomics.

12. AGRICULTURAL MICROBIOLOGY

Unit 1: History of Microbial World

History, development and scope of microbiology, evolution of microbial life. Theory of spontaneous generiation. Prokaryotes, archaebacteria and eukaryotes. Techniques used in identification and classification of bacteria. Important groups of prokaryotes – photosynthetic bacteria, blue green algae, chemoautotrophic bacteria, spore forming bacteria, mycoplasma, viruses, bacteriophages and actinomycetes. Heterotrophic bacteria nitrobacteria, nitrogen-fixing bacteria and cyanabacteria, lactic acid bacteria, halophiles, thermophiles acidophiles and methanogens. Structure and classification of viruses, growth of viruses, lytic and lysogenic cycles, plant viruses, viroids.

Unit 2: Microbial Ecology and Physiology

Principles of microbial ecology, Microbiology of ecosystems - soil, rhizosphere, phyllosphere, water - fresh and marine, and air. Microbial interactions - symbiosis, synergism, commenalism, parasitism, amensalism, antagonism and predation, adoption of micro-organisms to various ecosystems. Microbial growth curve. Mathematical expression of growth -continuous and batch cultures. Diauxic and synchronous growth. Microbial nutrition. Bacterial metabolism - aerobic and anaerobic respiration, electron transport chain, microbial photosynthesis, oxidative and substrate level photo-phosphorylation. Biosynthesis of cell wall, protein breakdown by microbes.

Unit 3: Soil Microbiology

Soil microorganisms: major groups, decomposition of organic matter, soil health. Root exudates and rhizosphere effects. Manipulation of rhizosphere microflora in plant productivity. Microbial biomass. Nitrogen cycle: ammonification, nitrification and denitrification. Biological nitrogen fixation–symbiotic and asymbiotic. Biochemistry and genetics of nitrogen fixation. Microbial transformations of phosphorus, sulphur and minor nutrients. Role of bio-fertilizers in agriculture and forestry. Bioremediation of problem soils, plant growth promoting rhizobacteria and their mode of action. Formation and composition of soil organic matter: fulvic acid and humic acid.

Unit 4: Environmental Microbiology and Basic Microbiological Techniques

Isolation and preservation of different types of microorganisms. Methods of sterilization and disinfection. Microscopy: Optical, phase contrast, fluorescent, dark field and electron. Microbial assay of vitamins, enzymes and antibiotics, Pollution of soil, water and air, Role of microorganisms in pollution, sources of pollution and their impact on environment, microbiology of sewage and industrial effluents and their safe disposal, management of solid and liquid organic wastes, composting, biogas, water purification, sewage treatment, water-borne diseases and effluent management.

Unit 5: Microbial Biotechnology

Industrial production of metabolites - organic acids, alcohols, antibiotics. Fermentor designs and types. Control of fermentation process - batch, feed batch and continuous. Downstream processing in fermentation industry. Production of single cell proteins and probiotics, hormones, biofertilizers, biopesticides. Phyto-remediation. Microbiology of raw and processed foods. Fermented food – vinegar, wine saucrkraut, pickles, cheese, yogurt. Food preservation, contamination and spoilage, food-borne illness and intoxication. Food as substrate for micro-organism, microflora of meat, fish, egg, fruits, vegetables, juices, flour, canned foods; bio-degrading microbes, single cell protein for use as food and feed, bioactive food / probiotics.

13. FRUIT SCIENCE

Unit 1: Orchard Establishment and Propagation and Nursery Management
Importance, area, production and distribution of fruit and plantation crops. Planning, layout and management of progeny orchards, nurseries. Collection of mother plants, planting, care, ideal propagation media, containers. soil sterilization. Raising of seedlings, rootstocks, and interstocks. Method and time of propagation of different fruit and plantation crops in different agro-ecological regions.

Unit 2: Rootstock and Nursery Management
Dormancy, seed germination, seedling growth, apomixis, polyembryony, root induction. Role of growth regulators and chemicals. Stock and scion relationship, incompatibility, propagation and hardening of different fruit and plantation crops and its commercial importance. Rejuvenation of old and unproductive orchards. Packing and transport of' nursery plants. Micropropagation-technique and stages, shoot tip grafting, clonal fidelity of TC plants.

Unit 3 Growth and Development
Dormancy, rest period, chilling requirements and heat units. Fruit bud differentiation in Physiology of flowering and chemical induction of flowering. Fruit set, development fruit drop and its control, parthenocarpy and seedlessness. Maturity and ripening. Biochemical changes associated with fruit ripening. Climacteric and non-climacteric fruits. Role of bioregulators in fruits production. Bearing habits. Unfruitfulness, alternate bearing, citrus decline, mango malformation, guava wilt, coconut-wilt, etc.

Unit 4 : Fruit Breeding
Principles, problems and prospects of fruit breeding. Methods of improvement e.g. introduction clonal selection, hybridization, mutation breeding, polyploidy and heterosis breeding. Breeding of new scion varieties and rootstocks. Crop improvement objectives. Inheritance of characters, problems and advances achieved in important fruit crops like mango, citrus, banana, grape, sapota, papaya, apple, pear, peach, aonla, pomegranate, coconut, arecanut, oil palm, cashew, tea, coffee, olive, cocoa, rubber, other minor fruits and plantation crops.

Unit 5: Fruits and Plantation Crops Production Technology
Improved production technology for fruit and plantation crops covering soil, climate, Propagation methods, varieties; planting, plant density, training and pruning. Factors related to nutrient availability, inter-relationship of elements. Organic farming and GAPs.

Unit 6: Production System and Management
Integrated nutrient and water management, weed, diseases including IPM and other orchard management practices of important fruit and plantation crops. Physiological disorders in fruit and plantation crops. Concept of high density planting, use of plastics, drip irrigation, fertigation cropping in hostile situations e.g. dry and wet lands, denuded forests, hill slopes, intercropping, mulching, multistory cropping, cropping in watersheds and precision farming.

Unit 7 : Pollinization
Role of pollination, pollinizors, role of insects, plants and rains, honey-bees in pollination of fruit and plantation crops, basics of maintaining bee colonies during flowering and off-seasons: multiplication of bee colonies, honey extraction, processing and storage of honey.

Unit 8 : Post Harvest Handling of Fruits and Plantation Crops
Harvesting technique, maturity standards. Handling of fruits and plantation crops. Grading storage and transport. Codex standards. Quality assurance system, value addition, primary processing, various products of fruits and plantation crops.

Unit 9 : Processing of Horticultural Produce
Product development, labeling of products, market assessment, quality management, food laws and its regulations, spoilage of products, factor affecting the spoilage, asceptic packing of products, freeze drying and development of new products, storage conditions for processed products and enhancement of shelf-life.

Unit 10 :Value Addition in Horticultural Crops
Importance of post harvest handling and processing for enhancing shelf life, value addition and value chain management; Current status of primary and secondary processing of horticultural produce in India and abroad. Various methods for enhancing shelf life of perishable horticultural produce. Importance of grading and packing for effective marketing and reduced losses. Factors affecting the processability of horticultural produce. Pre-harvest factors influencing the post harvest-life and processing quality.

Unit 11: Post Harvest Technology and Processing for Value Addition of Fruits
Importance of post harvest handling in fruit and plantation crops: maturity indices for harvesting and ripening, pre-cooling, various types of storage and storage temperature, grading, packing and transportation. Reefer containers and cold chain. Different methods of storage including controlled atmosphere storage, storage disorders and use of chemicals, skin coatings, growth regulators and irradiation for control of spoilage during storage and transit. Storage structures for different crops. Role of micro-organisms, enzymes and water activity in preservation, principles and methods of preservation by heat, chemicals, drying, radiation, freezing and fermentation. Methods of preparation of different processed products, fruit juices, beverages and concentrates. Canning, fruit jams, jelly and marmalades; Food laws, hazard analysis and critical control points (HACCPs), QM, GMP, investment analysis. Processing for value addition, product diversification in fruit and plantation crops.

14. VEGETABLE SCIENCE

Unit 1 : Principles of Vegetable Production

Introduction, economic and nutritive value of vegetables and spices. Production and productivity in India. Classification of vegetables and spices. Effect of temperatures, photoperiod, light relative humidity on production. Organic farming, Nutrients essential for plant growth, plant growth substances, chemical and bio-fertilizer and their response, irrigation and water requirements, Crop rotation, crop succession, inter and mixed cropping, weed control, different insects, nematodes and diseases and their management, role of plant growth substances.

Unit 2 : Production of Vegetables and Spices

Importance, origin, history, area, distribution, productivity, taxonomy. Climatic and soil requirements, commercial varieties and hybrids, nutritional requirements, irrigation, interculture, weed control, mulching plant protection and other cultural practices of warm and cool season crops i.e. solanaceous fruit vegetables, okra, cucurbits, *kharif* onion, early cauliflower, sweet potato, cowpea, cluster bean, Indian bean, colocasia, amorphophallus and amaranthus and production of tuber crops such as potato, tapioca, diascorea, sweet potato, yams, cole crops, root crops, bulb crops, pea, broad bean, leafy vegetables, high value vegetables, exotic vegetables.

Unit 3 : Biodiversity and Conservation of Vegetable Crops

Biodiversity and its role in conservation of in vegetables and spices - Genetic erosion and its consequences - Centres of diversity, exploitation and collection, germplasm maintenance. Characterization of landraces, wild species and other genotypes of vegetables and spices, cryobanks, quarantine, CBD and germplasm exchange aggrements.

Unit 4 : Principles of Breeding of Vegetable and Spice Crops

Principles of vegetable and spice crop breeding and importance. Genetic architecture, breeding systems, breeding methods. Ideotypes in different vegetables, F_1 hybrids, Superior selection and OP varieties, multiple disease resistance, Male sterility and imcompatibilities. Mechanisms of resistance, gene mining, biotechnological approaches for improvement in vegetable crops.

Unit 5 : Breeding of Self and Cross Pollination Crops

Origin, distribution, cytogenetics, genetics, breeding objectives and breeding methods used for improvement of self- and cross-pollinated vegetable crops, *viz*. tomato, brinjal. capsicum, garden peas, French bean, lablab bean, cowpea, clusterbean, broadbean, okra, lettuce, cole crops, cucurbitaceous crops, bulb crops, root crops, leafy vegetables and spices (Black pepper, cardamom, nutmeg, cinnamon, clove, allspice, tamarind, garcinia, vanilla, cumin, fennel, coriander and fenugreek).

Unit 6 : Biotechnology in Vegetable Crops

Improvement of vegetable crops and spices through biotechnological tools, viz. embryo culture and distant hybridization, protoplast fusion and somatic hybridization, *in vitro* selection and mutagenesis, application of molecular markers such as RFLP, RAPD, AFLP in vegetable improvement an dprecision breeding. Exploitation of genetic engineering for vegetable crop improvement and solving the problem of interspecific intergenetic barriers, development of vegetables with long shelf life, enhanced nutrient factors, etc.

Unit 7 : Principles and Techniques of Seed Production

History, importance and present status of vegetable seed industries in India and world. Agronomical and genetical principles of seed production. Definition of seed and its quality. Pollination systems in vegetable crops. Production and maintenance of nucleus, foundation and certified seed. Economics of seed production, IPR and WTO. Seed certification and seed laws, role of PPVFRA, genetically modified varieties and safety norms, seed storage and standards.

Unit 8 : Protected Cultivation of Vegetables

Objectives, importance and scope of protected cultivation of vegetable crops. Principles, Regulatory structures/systems used in greenhouse and glasshouses. Regulation of flowering and fruiting. Types of greenhouses, glasshouses, polyhouses, hot-beds, cold-frames, low tunnels, shade nets. Different media for growing nursery under cover, sterilization techniques, Specific technology for raising tomato, sweet pepper, cucumber and other high-value vegetables in greenhouse. Insect, nematode, virus and disease; pollination management in greenhouse production, water quality and conservation techniques, microirrigation and fertigation, Naturally ventilated and automated structures, harvesting and primary processing and packaging of produce. Protectyed production of high-value vegetables under protected structures, Importance and types of mushroom cultivation, medicinal and speciality mushrooms.

Unit 9 : Post -Harvest Management of Vegetables

Structure and composition of vegetables. Maturity indices, harvesting, grading methods. Physico-chemical changes during ripening and storage. Physiological processes - respiration, transpiration and ethylene biosynthesis and their influence on storage quality and senescence. Pre-storage treatments for quality retention and regulation of ripening using chemicals, growth regulators, fungicides; Irradiation. Packages and packing house operations; Storage systems. Pre-cooling, Low temperature, Controlled Atmosphere (CA), Modified Atmosphere (MA) and Hypoboric storage. On-farm storage: Storage requirements of vegetables and mushroom; Post harvest management of mushrooms. Storage disorders; Spoilage and their control; Transportation, marketing and export requirements. Processing of vegetables, drying of vegetables, canning of vegetables, other vegetable products. GAPs and minimal residue levels in fresh produce.

15. FLORICULTURE

Unit 1 : Principles of Floriculture and Landscaping

Importance and scope of floriculture. History, types and development of gardens. Factors affecting growth and development of ornamental horticulture. Cultivation of ornamental trees, shrubs, climbers, ground covers, bedding and bulbous plants. Nursery management techniques. Cacti and succulents, ferns, palms and foliage plants. Introduction to commercial floriculture-traditional flowers, cut and loose flowers production of important flower crops including cost of production. Use of plant growth regulators in floriculture, structures used in floriculture. Preparation of bonsai. Flower shows. Flower arrangements. Principles and elements of landscaping. Garden features and adornments.

Unit 2: Turf Grass Management

Introduction - history, value and prospects of turf grass industry. Turf grass environment. Light, Temperature, water, air, and soil for turf grass. Types of grasses - species - combinations – planting techniques, cultural practices - mowing – rolling-fertilization, irrigation, Pests and diseases – turf management, mixing of lawns with other components.

Unit 3 : Indoor Plants and Interior Scaping

Importance and scope of house plants and interior scaping. Factors affecting growth and flowering of house plants. Containers and potting media. Plant care including propagation, training, grooming, nutrition. Care and maintenance of indoor plants. Description and cultivation of various house plants. Principles of interior scaping. environmental consideration. Special gardens like dish, terrarium, hanging baskets. window boxes, miniature gardens, plant stand and vertical gardens, rare ornamental and speciality plants.

Unit 4 : Flower Arrangement and Value Addition

Importance and scope of flower arrangements, principles and types. Vases and materials used in flower arrangements for different occasions like festivals, marriages, social functions, making of bouquets, corsages, *gajra*, *rangoli*, *veni*, button holes, wreaths etc. Dry flower and foliage production, arrangements and packing. Economic considerations for flower arrangements and processing for exports. Ornamental crops for value addition, production of esssntial oils perfumes, nutraceuticals etc. Processing technologies and product diversification, export potential and commerce.

Unit 5 : Production Technology of Ornamental Crops

Present status of floriculture, medicinal and aromatic plants in India and its potential in the global market. Breeding strategies for development of new cultivars of ornamental flowers. Commercial production of field flowers, bulbous, foliage and pot plants. Specific problems concerning production of roses, chrysanthemum, carnation, jasmine, marigold and other minor cut flower crops. Especiallity flower and foliage crops carnation, rose, orchid, anthurium, BOP, culture. Production of essential oil yielding flowers. Major insects, nematodes, diseases, physiological disorders and their management. Processing and extraction of active ingredients in important medicinal plants. Harvesting and Pacakging protocols for different flower crops.

Unit 6 : Landscape Horticulture

Principles of art and their application in landscape compositions and interior decoration. Man as the human habitat. Natural and man-made forms and features. Analysis of various types of sites and their landscape treatments. Organization of spaces. Visual aspects of plan arrangement-view, vista and axis. Principles of circulation. Garden structures. Analysis of problems and application of landscaping principles for various types of cities, houses, educational institutions, religious places, industrial sites, country side, farm complexes, embassies, hotels and other buildings. Special problem of landscaping of terrace, roof gardens and multistory buildings. Factors affecting outdoor recreation. Selection of sites and their landscaping for various categories of tourist complexes, picnic spots and camping grounds. Coputer-aided designing and achitectechtural planning.

Unit 7 : Medicinal and Aromatic Plants

Importance of medicinal and aromatic plants in India and abroad. Classifications of medicinal and aromatic plants. Commercial production technology and processing of importrant aromatic and medicinal plants. Improvement of medicinal and aromatic plants through breeding methods, varieties, propagation and maintenance of genetic purity, Nursery management and seed production. Organic and greenhouse cultivation, nutrient and water management, insect pests and diseases, extraction procedures of essential oils in aromatic plants, primary processing in medicinal and aromatic plants. Organizational support for the promotion of medicinal and aromatic plants.

Unit 8 : Post Harvest Managements of Cut-flowers, Foliage and Pot plants

Importance of handling, maturity, types of storages, containers, pre-cooling, transport, export, methods and economy vase-lfe physiology of cut flowers, pulsing and holding solution, grades and pacakaging of cut and losse flowers, primary and secondary processing, national and International cut flowrer trade and standards, refer chain and cool chain mamagemenet, market intelligence and e-auctioning, Governement supported schemes and promotional activities. Important foliage and pot plants for domestic and export markets. Standards and export norms.

16. ANIMAL PHYSIOLOGY

Unit 1:Cellular Basis of Animal Physiology
Animal cell ultra-structure, composition and functions. Physio-chemical laws and membrance phenomena. Body fluid and its dynamics. Transport of through biological menbrance.

Unit 2:Blood and Circulation
Composition of blood, structure & functioning of its constitutes. Blood coagulation and anti coagulants. Hemoglobin and its polymorphism. Anaemias. Sreticule-endothelial System. Body defense mechanism and immunogenesis.

Electrophysiology of heart. Electro-cardiography – Principles and interpretation. Hemodynamics and concerned biophysical principals. Capillary fluid exchange and lymphatic circulation. Neural and humoral control of heart and blood vessels. Cardiac Output and vascular reflexes. Autoregulation mechanism in the heart Regional circulation – coronary, pulmonary, cerebral, muscle, kidney and skin, blood brain barrier. Circulatiory shock and hypertension and cardiac failure.

Unit 3: Respiration
Mechanics of respiration. Neural and chemical control of respiration. Gaseous transport and exchange. Hypoxia. Physiology of hypo-barrism and high altitude. Work and exercise physiology. Respiration in birds.

Unit 4:Excretion
Modern concepts of urine formation. Control of renal circulation. Secretion and absorption in renal tubules. Regulation of acid-base balance by blood buffers, lungs and kidneys. Hormonal and renal regulation of body fluids and electrolyte balance. Physiology of micturition. Uremia and other renal disorders. Renal functions in birds.

Unit 5:Digestion
Control of motility and secretion of alimentary canal. Gastric hormones and reflexes in the control of digestive functions. Control of rumen motility. Digestion in ruminant and monogastric animals. Absorption from rumen and the digestive tract. Manipulation of rumen microflora to enhance fibre digestion and microbial protein synthesis. Nitrogen recycling and rumen bypass mechanisms. Post-ruminal digestion. Physiology of rumen disorders. Avian digestion (different features).

Unit 6: Muscle Physiology
Muscle types and their intra-cellular contractile mechanisms. Electrophysiology of muscles. Neuromuscular junction. Excitation contraction coupling, its biochemical and ionic mechanisms. Molecular basis of muscle contraction. Rigor mortis.

Unit 7: Nervous System

General organization of nervous system. Neurone structure and fuction. Excitability and transmission of impulse in neuron and muscle. Junctional transmission. Neuro-transmitters. Reflex action. Initiation of impulses from sense organ / receptors. Functions of spinal cord, brain stem and cerebellum. Limbic system and cerebral cortex. Hypothalamus and its autonomic functions in endocrine and visceral regulation. Ascending and descending tracts. Cerebral cortex, its role in motor and sensory functions. Physiology of learning and memory. Physiology of pain. Special senses (hearing, vision, taste, smell etc.).

Unit 8: Endocrinology

Hormones. Hormone receptors. Mechanism of hormone action at cellular and sub – cellular levels. Feedback control of hormone secretion. Hypothalamic – hypophyseal axis. It should include (i) Hypothalamic – hypophyseal axiz controlling secretions from thyroid, parathyroid, adrenal and gonals, (ii) Endocrine control of general metalbolism. Releasing and inhibiting factors.

Pineal gland and its hormones. Hormones of hypophysio and all other endocrine glands. Mechanisms of different hormone actions. Endocrine disorders.

Unit 9: Reproduction

Gonadal hormones and their functions in male and female. Neuro-endocrine-gonadal axis and feedback regulation. Male spermatogenesis. Accessory sex glands. Sexual behaviour erection, ejaculation etc. Semen evaluation. Factors affecting reproduction. Artificial insemination – collection, preservation and transport and semen diluents. Freezing of semen. Oogenesis. Follicular development. Ovulation. Corpus lutetium. Reproductive cycles in animals. Factors affecting reproductive cycles. Female reproductive hormones. Oestrous synchronization, super-ovulation. Sperm capacitation and acrosomal reaction. Sperm and ovum transport in female genital tract. Fertilization. Implantation. Maternal recognition of pregnancy, Maintenance of pregnancy and its hormonal control. Physiology of placenta. Physiology of parturition and its hormonal control. Embryo transfer – collection, preservastion, transport and transfer of embryos. Oocytculture. In vitro fertilization. Mammary gland growth before puberty, during pregnancy and after parturition and its hormonal control. Lactation-Hormonal control of lactation and milk let-down. Maintenance and cessation of lactation. Mammary gland involution. Milk precursors and synthesis of milk constituents. Methods of studying mammary uptake of nutrients, Ultrastructure of lactating mammary gland. Milk composition in different animals. Avian reproduction-ovulation, egg formation, oviposition and their hormonal control. Spermatogenesis and semen composition.

Unit 10: Physiology of Growth

Concept and definition. Growth regulation and factors affection prenatal and post-natal growth. Role of growth in production. Growth curve and growth measurement, body confirmation and evaluation of carcess quality.

Unit 11: Climate Physiology

Physiology of climate stress. Effects of stress on production and reproduction. Neural and hormonal regulation of body temperature in homeotherms. Machanism of adaptation. Photoperiodicity and biological rhythms. Design of shelters / animal houses for different class of livestock for different climate conditions.

Unit 12: Behavioral Physiology

Different types of behaviour in animals like feeding, grazing, drinking and thermoregulatory behaviour, neuro-endocrine control of behaviour in livestock.

17. BIOCHEMISTRY (ANIMAL SCIENCES)

Unit 1:
Scope of Biochemistry and molecular biology in animal sciences. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriphages. Compartmentalization of metabolic processes within the cell and fractionation of subcellular components. Structure and functions of biomembranes with special reference to active transport of ions and metabolites. Extra and intracellular communication. General description of cell culture, hybridoma and animal cloning techniques.

Unit 2:
Structure and properties of biologically important carbohydrates including storage and structural polysaccharides, mucopolysaccharides, blood group substances, peptidoglycans and bacterial polysaccharides. Structure and properties of fatty acids, acyl glycerol, glycerophospholipids, sphingolipids, glycolipids, sulfolipids, aminolipids, sterols, bile acids and prostaglandins. Basic principles of isolation, estimation and analysis of carbohydrates and lipids.

Unit 3:
Aminoacids, structure and properties. Primary, secondary, tertiary and quaternary structure of proteins. Glycoproteins, lipoproteins, nucleoproteins, fibrous and globular proteins. Structure and functions of immunoglobulins, myoglobin and hemoglobin. Physical and chemical properties of proteins. Structure of different types of nucleic acids. Acid base properties, sedimentation behaviour, hyperchromic effect, base sequencing and restriction analysis of DNA. Computer applications in molecular biology, primer designing, sequence analysis and phylogenetic analysis.

Unit 4:
Major classes of enzymes, general proerties, kinetics and mechanism of their action. Activation energy and transition state. Coenzymes and cofactors. Regulation of enzyme activity and enzyme inhibition. Isoenzymes and enzymes of clinical significance. Applications and scope of enzymes in bioprocess technology and genetic engineering.

Unit 5:
Bioenergetics, biological oxidation, respiratory chain and oxidative phosphorylation. Citric acid cycle and ATP generation. Glycolysis, pentose phosphate pathway and glycogenesis. Biosynthesis and oxidation of fatty acids. Volatile fatty acids as source of energy in ruminants. Ketogenesis and cause of ketosis in ruminants. Biosynthesis of sterols and phospholipids. Catabolism of amino acids, transmination and determination, urea cycle. Intergration of carbohydrate, lipid and amino acid metabolism. Conversion of amino acids into other bioactive compounds. Biosynthesis of nutritionally non-essential amino acids. Metabolism of purines and pyrimidines. Disorders of lipid, carbohydrate, nucleic acid and amino acid metabolism. Inborn errors of metabolism and scope of gene therapy in combating genetic disorders.

Unit 6:
Mechanism of storage, transmissions and expression of genetic information. DNA replication and control of gene expression in prokaryotes and eukaryotes. RNA synthesis and factors regulating transcription. Biosynthesis of proteins. Features of genetic code in prokaryotes and eukaryotes. Wobble hypothesis, post-translational modification, degeneracy and regulation of translation. Basic principles of recombinant DNA technology and its scope in animal health and production. Recombinant proteins and vaccines, safety, ethical issues and IPRs in molecular biology.

Unit 7:
Structure and metabolic functions of water soluble and lipid soluble vitamins. Trace elements and their role in biological processes. Deficiencies and nutritional significance of vitamins and trace elements in domestic animals and poultry, neutraceuticels & probiotics. General description of nature of hormones, receptors and mechanisms of their action. Metabolic function of different hormones and associated disorders due to hypo or hyper secretions of major endocrine glands viz. pituitary, thyroid, adrenal, pancreas and gonads.

Unit 8:
Blood composition and biochemical constituents of erythrocytes, leucocytes and platelets. Important plasma proteins and their functions. Haemoglobin in oxygen and carbon dioxide transport. Role of kidneys in acid base balance. Composition and metabolism of muscle, connective, tissue, cartilage, bone, nervous, tissue, adipose tissue and mammary tissue. Clinical significance of iron, iodine calcium and phosphorus metabolism in domestic animals and poultry. Biochemical tests for hepatic and renal functions. Urine composition and analysis.

Unit 9:
Basic principles and use of latest photometric, chromatographic, eletrophoretic and redioisotopic methods of biochemical analysis. Mehods of isolation, purification and characterization of proteins, DNA and RNA. Basic principles of RIA, ELISA, PCR, RFLP and DNA fingerprinting NA probes, vectors, microarray, imaging, applications of nanotechnology, proteomics. Determination of enzymes, hormones, vitamins and other biochemical constituents with special reference to disease diagnosis in domestic animals.

Unit 10:
Environmental pollution in relation to animal health and production. Biotechnology in pollution control. Biochemical basis of pollutant tolerance, host defence mechanisms including antigenic and non-antigenic interactions. Free radicals, carcinogenesis and role of liver and kidneys in detoxification. Oncogenes and mechanism of immuno suppression in cancer therapy and organ transplantation.

18. ANIMAL BIOTECHNOLOGY

Unit 1:Cell Biology

Prokaryotic and eukaryotic cell architecture. Molecular organization and functions of cell membrance. Organisation and functions of the cytoplasm, cell organelles, endoplasmic reticulum, ribosomes, Golgi complex, mitochondria, Iysosomes, nucleolus and subnuclear structures. Protein secretion and targeting. Intracellular digestion. Oxidative phosphorylation.

Cell division. Cell growth and differentiation. Control of proliferation and self regulation. Cell motility. Cell trafficking and signaling. Apoptosis.

Unit 2: Molecular Biology

DNA replication in prokaryotic and eukaryotic cells. Structure and functions of DNA polymerases. Molecular mechanisms of DNA repair. Synthesis and processing of different types of RNA. RNA polymerases. Protein biosynthesis.

Genetics of mitochondria and plasmids. Transposons and intervening sequences. Minisatellites and macrosatellites. Molecular mechanism of spontaneous and induced mutations. Site directed mutagenesis.

Recombination in bacteria, fungi and viruses. Molecular mechanism of genetic recombination, transduction, transformation and conjugation.

Unit 3: Gene Structure and Expression

Organisation of prokaryotic and eukaryotic genome. Repeated and non-repeated DNA sequences. The structure and chemical nature of the gene.

Expression of genetic information, transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhncers, transcription factors, post-transcriptional modifications. DNA-protein interactions.

Genetic code. Mechanism of translation and its control, post-translational modifications. Control of gene expression in prokaryotes and eukaryotes.

Unit 4: Genetic Engineering and Recombinant DNA Technology

Isolation and purification of DNA / RNA from prokaryotes / eukaryotes. Reverse transcription. Restriction endonucleases. Generation of DNA fragments, Cloning and expression vectors, plasmids, cosmids, phages, viruses (vaccinia, herpes, retrovirus and adenovirus), shuttle vectors.

Cloning and expression in prokaryotic and eukaryotic hosts. DNA libraries, screening and characterization of DNA clones, transformation of bacterial and animal cells.

Oligonucleotide synthesis. *In situ* mutagenesis. DNA amplification. Production of diagnostics and vaccines using r-DNA technology. Genetically modified foods / products. Genetic manipulation of rumen microbes.

Safety aspects of genetic engineering. Ethical issues related to use of biotechnology products. Patenting and Intellectual Property Rights.

Unit 5: Animal Tissue culture and Hybridoma Technology

Development of cell (tissue) and organ culture techniques. Nutrient requirements of mammalian cells. Media for culturing cells. Growth supplements. Primary cultures. Established cell lines. Stationary, Roller and Suspension culture techniques. Large-scale production of cells using bioreactors, microcarriers and perfusion techniques.

Characterisation and maintenance of cells, karyotyping, cryopreservation and revival. Detection of contaminants in cell cultures. Isolation and culture of lymphocytes. Application of cell and organ cultures.

Micromanipulation of cells. Cell cloning. Cell fusion and Somatic cell hybrids. Principles and methods of hybridoma technology. Production and characterization of monoclonal antibodies and their application in animal health and production.

Unit 6: Embryo Transfer and Related Techniques

Induction of superovulation. Embryo collection and evaluation. Embryo splitting. Embryo sexing. Embryo transfer. Advantages of embryo transfer in farm animals.

In vitro fertilization. Embryo cloning. Nuclear transplantation. Production of transgenic animals and gene farming. Identification and transfer of gene influencing production and disease resistance.

Unit 7: Molecular Biology Techniques

Quantitation of nucleic acids. Gel electrophoretic techniques. Isolation of plasmids. Production of radioisotopic and non-rodioisotopic probes. Nucleic acid hybridization. *In situ* hybridization radioisotypic methods of biochemical analysis. Autoradiography. Blotting techniques. Nucleic acid sequencing methods. Methods of peptide synthesis. Protein purification methods. Restriction Fragment Length Polymorphism (RFLP). DNA fingerprinting. Polymerase Chain Reaction (PCR). Computer applications in molecular biology. Animal cloning and transgenic technology.

19. VETERINARY ANATOMY

Unit 1:Gross Anatomy

Ox as a "Type" animal and structures of other domestic animals in comparison. Bones of fore and hind limbs, axial system viz. skull, vertebrae, ribs and sternum in domestic animals. Joints, their classification and important joints in ox. Myology in general, muscles of appendicular and axial system in ox. Heart, systemic and pulmonary circulation. Arota and its important branches in thoracic and abdominal regions. Blood supply of fore and hind limbs. Venous drainage of fore and hind limbs, head, neck, thorax and abdomen and portal circulation in ox. Superficial lymph nodes of ox in relation to antemortem and postmortem examinations. Thymus and spleen in general. Cisterna chili and major lymphatic ducts of head, neck, thorax and abdomen. Organs of digestive, repiratory, urogenital (in male and female) and nervous systems. Topographic location of organs in domestic animals in relation to their surgical sites and clinical examination. Endocrine glands-pituitary, adrenal, thyroid and parathyroid glands of ox. Organs of snese-eye, internal ear, integuments and hoof. General principles of biomechanics during locomotion and weight bearing.

Unit 2

Study of various bones and organs of digestive, repiratory and urogenital system in fowl.

Unit 3:**Micro-anatomy**

Definition of histology and preparation of histological slides. Microscope and microscopy. Light and ultrastructural picture of animal cell. Basic tissues of the body-epithelium, connective tissue, muscular and nervous tissues in general. Micro-anatomy of important organs of digestive system viz. tongue, tooth, oesphagus, stomach, intestine, liver and pancreas. Respiratory organs viz. nasal cavity, trachea and lungs. Urinary organs- kidney, ureter, urinary bladder and urethra. Genital organs of male- testis, epididymis, ductus deferens. Accessory sexglands in male-prostate, seminal vesicles and bulbo- urethral gland and penis. Genital system in female-ovary, oviduct, uterus, vagina, vulva and mammary glands. Sensory organs of smell, taste, vision, hearing and touch. Endocrine glands- pituitary, pineal, thyroid, parathyroid and adrenal glands. Lymph nodes, spleen, thymus and bursa (of Fabricious).

Unit 4: Developmental anatomy

Embryology and its scope in veterinary practice. Gametogenesis, fertilization, cleavage, gastrulation and establishment of three germinal layers. Intra and extra embryonic membranes of chick and mammals. Placentation in mammals. Morphogenesis and histogenesis of digestive, repiratory, urinary and genital organs, blood vascular and nervous sytems in mammals and chicks. Development of eye, ear and endocrine glands.

20. VETERINARY PATHOLOGY

Unit 1: Introduction, History and Etiology

Introduction, history and scope of pathology. Definitions. Etiology of the disease. Predisposing factors, intrinsic and extrinsic factors responsible for the disease. Physical agents, mechanical injuries. Heat, cold and decreased atmospheric pressure, light (photosensitization) UV light, microwaves, electricity, chemical agents-exogenous chemicals (toxin, poisons, drugs and food substances), endogenous chemicals (metabolites, cytolytic or inhibitory immune complexes, free radicles, oxidants)

Unit 2: Haemodynamics Derangements, Degeneration and Necrosis:

Disturbances of circulation / haemodynamic derangements hyperaemia, ischaemia, haemorrhage, sludged blood, thrombosis, embolism, infarction, oedema and shock. Disturbances of cell metabolism – protein, carbohydrate and lipid metabolism, pigment metabolism, pathological calcification / ossification. Apoptosis, necrosis, gangrene. Ultrastructural changes in cell organelles in haemodynamic derangements and cell metabolic disturbances.

Unit 3: Inflammation and Healing

Inflammation – definitions associated with inflammatory phenomenon, etiology of inflammation, cardinal signs, pathogenesis of inflammation, chemical mediators released from injured tissues and inflammatory cells. Cellular reponse in inflammation, structure and functions of cells associated with inflammation. Role of humoral and cell mediated defenses. Various classifications of inflammation. Healing, cellular regeneration capability of different body cells. Role of cells (macrophages, fibroblasts, myofibroblasts, endothelial cells), extracellular matrix components and growth factors in healing.

Unit 4: Immunopathology

Immunopathology – anibody and cells, immuno-competence of foetus and new-born. Immune mediated tissue injury, hypersensitivity reactions- anaphylaxis, Arthus reaction, cyototoxic antibody reaction, immune complex disease, delayed hypersensitivity to chemicals, immuno-deficiency diseases, defective immuno-competence, autoimmune diseases.

Unit 5: Genetically Determined Diseases

Genetic abnormalities, aberrations of chromosomes, mosaicisi, chimerism, anomalies in sex chromosomes and it autosomal chromosomes. Pathological states determined by one or more genes, lethal genes.

Unit 6: Disturbances in Cell Growth and Oncology

Disturbance in cell growth – aplasia, hypoplasia, hyperplasia, atrophy, metaplasia, dysplasia. Neoplasms-growth, etiology, classification, morphology, and behaviour of the neoplasms, structure and biology of the tumor cell, tumor immunology, tissue response to tumors, spread of humors, pathological features of various neoplasms.

Unit 7:Postmortem Diagnosis and Histopathological Techniques
Posmortem examination as a diagnostic tool. Postmortem techniques for different species including poultry, postmortem changes, lesions in various organs in different diseases, identification and interpretation of lesions, preparation of necropsy reports. Handling of necropsy in vetero-legal cases, collection, preservation and dispatch of materials for diagnosis. Fixation and processing of tissues for histopathology and histochemistry. Different staining techniques. Histochemistry and histoenzymology as diagnostic tools. Principles of electron microscopy, processiong of tissue for scanning and transmission electron microscopy.

Unit 8: Clinical Pathology
Clinical laboratory examination of various biomaterials from different livestock species, complete blood counts, serum enzymology, bone marrow examination, erythrocytes, leucocytes and platelet disorders and their interpretations. Electrolyte and acid base analysis, altered electrolyte concentrations and their interpretations, fluid accumulation disorders, examination of effusions (chemistry and exfoliative cytology). Complete examination of urine, skin scrapings stools, CSF and milk for pathological constituents and interpretation of results.

Unit 9:Systemic Pathology
Pathology of cardiovascular, haemopoietic, respiratory, digestive, urinary, genital, nervous and musculoskeletal systems, endocrine glands, organ of special senses i.e, eye, ear, skin, appendages.

Unit 10: Pathology of Infectious Diseases
Pathology of bacterial, mycotic, viral, mycoplasmal, rickettsial, chlamydial and parastic diseases. Diseases caused by prions.

Unit 11: Avian Pathology
Farm placements and building in relation to disease, management and nutrition in relation to disease. Biosecurity in the control of diseases. Stress and its effects. Omphalitis and yolk sac infection, Newcastle disease, infectious bronchitis, infectious laryngio-tracheitis, viral arthritis, infectious bursal disease, egg drop syndrome, inclusion body hepatitis and hydropericardium syndrome, infectious stunting syndrome, swollen head syndrome, Marek's disease, avian leucosis / sarcoma complex, salmonellosis, pasteurellosis, mycoplasmosis, chalamydiosis, colibacillosis, spirochaetosis, aspergillosis, thrush, mycotoxicosis, parasitic diseases – nematodes, cestodes and protozoa, nepherosis / nephritis syndrome, multi-etiology syndromes. Immunosuppression and conditions / diseases associated with it. Vaccinations against various diseases, their failures and remedies.

Unit 12: Nutritional and Production Pathology
Pathology of nutritional deficiency disease – protein, carbohydrate, mineral and vitamins. Concept of production diseases – pathology of milk fever, ketosis, magnesium tetany, rumen indigestion, nutritional haemoglobinuria.

Unit 13:Pathology of Toxicosis
Clinicopathological features of toxicosis due to heavy meals, mycotoxins, insecticides, pesticides, toxic plants, chemicals and drugs.

Unit 14: Pathology of Diseases of Laboratory and Wild Animals
Etiopathology of common diseases of laboratory and wild animals.

21. VETERINARY PARASITOLOGY

Veterinary Helminthology (Platyhelminthes, Nemanthelminthes), Veterinary Entomology (Insecta and Acarina), Veterinary Protozoology (Parasitic Protozoa), Clinical Parasitology, Parasitic Zoonoses, Diagnostic Parasitology, Management of Livestock Parasitism, Immunoparasitology, Antiparasite drug testing guidelines.

Unit 1: Veterinary Helminthology
Introduction to veterinary helminthology, general account of morphology, classification, life-cycle patterns, epizootiology, pathogenesis, symptoms, diagnosis; treatment and control of parasites belonging to the various families.

Unit 2: Veterinary Entomology:
Introduction to veterinary entomology, classification, distributions, morphology, life-cycle, seasonal patterns and economic significance of insects and acarines belonging to the various families. Treatment, control and integrated arthropod pest management. Current advances in immunological interventions/ Control of arthropods.

Unit 3: Veterinary Protozoology:
Introduction to veterinary protozoology, classification, morphology, life-cycle, clinical symptoms, pathogenesis, diagnosis, chemotherapy, prophylaxis and control of parasites belonging to the various families.

Unit 4: Clinical Parasitology:
Clinical and parasitological signs of parasitic infections in domestic animals, Parasitic diseases of skin, eyes, alimentary, respiratory, urinary, genital, nervous, cardio-vascular and haematopoietic systems. Keys to indentification and different diagnosis of helminthic eggs, nematode larvae, gravid proglottids of major tape worms, blood protozoans and apicomplexan group of parasites.

Unit 5: Parasitic Zoonoses
Introduction and importance of parasitic zoonoses, classification of parasitic zoonoses, geo-veterinary and epidemiological aspects including factors influencing prevalence, distribution and transmission of diseases. Role of reservoir hosts, natural habitat, wildlife and their public health significance, clinical features, pathology, diagnosis, treatment, control and prophylaxis of zoonotic parasitic infections.

Unit 6: Management of Livestock Parasitism
Factors affecting epidemiology, host environment, development and survival of infective stages, microhabitat, seasonal development (hypobiosis/diapause), dietary and host factors altering susceptibility, concurrent infections. Influence of genetic factors, general approaches to control of parasitic diseases – stock management practises, stock rates, rotational grazing, clean grazing. Parasite worm burden (EPG). Strategic and tactical control strategies involved in chemical control of helminth, protozoan and arthropod infestations. Broad and narrow-spectrum anthelminitics, antiprotozoal drugs, insecticides and acaricides. Newer drug delivery systems-

slow and pulse release methods. Anthelmintic failure – drug resistance monitoring and management. Prospects of alternative methods of control, breeding for host resistance against parasites. Control of vectors and intermediate hosts and sustainable management. Estimation of economical losses due to parasitic diseases.

Unit 7: Immuno Parasitology

General principles of parasitic immunity and immune responses to helminths, protozoa, arthropods – The adaptive immune responses, evasion of immunity, classical antiparasite responses – concomitant immunity, premunition, spring-rise, self-cure, VLM, CLM, parasitic granuloma, nodule formation, Parasitic antigens relevant to immunity and diagnosis, their identification and purification-general protocols, immunomodulators and their use in immunopotentiation. Demonstration and characterisation. Development of live, attenuated, killed and new generation vaccines.

Unit 8: Diagnostic Parasitology

Laboratory diagnostic procedures for parasite identification and detection, coprodetection techniques, floatation/concentration, methods, direct microscopy, parastic staining and special techniques used in parasite identification. Culture and identification of nematode larvae, cercaria, identification of metacestodes and animal infestation, methods for parasite isolation. Diagnostic procedures for manage and bot infestations. General immunodiagnostic assays (ELISA, IFAT, Dot-ELISA, EITB). Principles of validation of diagnostic assays, and OIE recommendations for diagnosis and knowledge of referral laboratory of O.I.E. and molecular techniques used in parasite epidemiology and diagnosis.

22. VETERINARY PUBLIC HEALTH

Unit 1:Veterinary Public Health
Definitions, concept of Public Health, Intersectoral approach to Human Health, Veterinary Medicine, Veterinary Public Health, Human health goals, veterinarians participation in public health and justifications, Veterinary Public Health Unit – its dimensions and functions, National and International organizations related with Public and Veterinary Public Health, Rural health, Role of Public Health Veterinarians in Public Health, Health Delivery System.

Unit 2:Milk Hygiene
Definitions, Dairy Industry and milk hygiene in India and other countries, Microbiology, of milk and milk products, microbial spoilage of milk and its products, Bacteriophage, Contamination of milk and its products, Public health aspects of residues: agricultural chemicals, antibiotics and drugs, toxic metals, plant toxins, mycotoxins and adulterants, Milk borne diseases, Milk hygiene, Hygienic aspects of production of milk and processing and manufacture of milk products, Clean milk production, Prevention of contamination by sanitation at dairy farm, collection centers, milk processing and manufacturing plants. Pasteurization, Sterilization, Standards. Quality control tests applied to milk and milk products.

Unit 3:Meat Hygiene
Definitions, Meat industry and meat hygiene in India and other countries. Raising meat food animals and birds, their trade and transport. Hygienic aspects of slaughter, bleeding, dressing and processing and manufacture of carcass meat and meat products. Rigor mortis, Emergency and causality slaughter. Abattoir/ Meat plant Sanitation, Microbiology of meat and their products. Sources of contamination, Disposal and reclamation of slaughterhouse wastes and byproducts and associated public health problems. Spoilage of meat and meat products, Preservation of meat. Meat food safety, Ante mortem and post mortem examination, Inspection of poultry meat, eggs, fish and meat from game animals, Judgment, Indices of sanitary quality, National and International standards, Bacteriological, serological and biochemical tests for quality control, substitution and adulteration.

Section 4: Food-borne Infections and Intoxications:
Definitions, Classifications of Food borne diseases, Meat-borne diseases, Milk-borne diseases, Infections and intoxications traced to consumption of fish/eggs, Fast/Street/Convenience foods, Epidemiological characteristics of food-borne infections and intoxications, Sources of pathogens and factors favouring for poisoning, bacterial, viral, protozoan, helminthic, mycotic and chemical food poisoning, Epidemiological investigation of food-borne infections and intoxications, Food specific attack rate. Odd ratio, Detection of foodborne pathogens and their toxins. Management of food poisoning.

Unit 5: Zoonoses
Definitions, Concept and classification of Zoonoses, Ecological aspects of Zoonoses, Wild animals-, cold blooded animals - domestic animals -, and aquatic life, -associated Zoonoses, Vectors-, milk-, meat-, egg-, fish- and water- spread Zoonoses, Occupational zoonoses, Nosocomial zoonoses, xenozoonoses, Nationally and internationally emerging and re-emerging

Zoonoses, Epidemiology of bacterial, rickettsial, viral, parasitic and mycotic Zoonoses, Principles of Zoonoses management: methods of prevention, control and eradication of Zoonoses.

Unit 6: Environmental Hygiene

Natural sources of water, water hygiene, Pure and wholesome water; microbial contamination and chemical pollution of water, Impurities in water, plankton, Purification and sanitization of water, Waterborne diseases, Microbiological examination of water, Potable water, Standards for drinking water. The atmosphere. Air Pollutants, Air-borne pathogens and diseases, Ventilation, Methods of air purification. Agricultural chemicals, industrial wastes, domestic and farm effluents polluting environment – and associated hazards and preventive measures. Antibiotic and pesticide residues and their effect on health. Waste-recycling, Methods of disposal of dead animals. Rodents and Vector control measures.

Unit 7: Epidemiology

Definitions, Epidemiology, Epizootiology, Casual association, concept of infection, Theory of natural nidality, Ecological basis of diseases, Disease transmission, Epidemic process, Distribution of diseases in space and time, Epidemiological hypothesis, Types of epidemiological studies, Epidemiological survey, surveillance, monitoring of diseases, experiemental epidemiology, epidemiological measurements, Predictive epidemiology, Epidemiological models, Sero-epidemiology. Use of information technology and computer applications in disease monitoring, Epidemiological investigation and evaluation of intervention measures.

Unit 8: Experimental Animal Medicine

Occupational health and safety in the care and use of research animals. Breeding, care and management of experimental animals, Production of gnotobiotic, germfree, specific pathogen free, transgenic, syngenic animals and tailor-made animals in relation to public health, provisions of Animal welfare and Society for Prevention of Cruelty to Animals Act.

Unit 9: Health Education

Health education, communication techniques, Participatory programmes for awareness creation among agricultural workers, butchers, laboratory staff and those engaged in zoological gardens, laboratory animals rearing, processing of animal produce about occupational hazards and hazards to consumers.

Unit 10: Standard Guidelines and Legislation

Definitions, standards / guidelines of products and product ingriedients. Hazards Analysis Critical Control Points (HACCP), Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP), Milk and Milk Product Order (MMPO), Meat Food Products Order (MFPO), Total Quality Management (TQM), Quality assurance and food safety management systems, Bureau of Indian Standards, International Organization for Standards, Codese Alimentarius, World Trade Order, Sanitory and Phyto-sanitory (SPS) measures, Technical Barriers to Trade (TBT), National and International Standards related to milk, meat, fish and their products and hygienic standards to ensure safety to domestic and foreign consumers of products of animal origin.

Unit 11: Microbiology in Public Health

Food microbiology, Characters of food bacteria, moulds, yeast and virus, Classifications of food microbes according to their requirements for growth – temperature, acidity, moisture, oxygen and salt concentration, resistance to microenvironment, Food processing and preservation methods. Pathogen- virulence factors, microbial enzymes, toxic metabolites and other molecules associated with pathogenic mechanisms. Resistance mechanism of survival in environment in and outside the host, Antigens eliciting protective and diagnostic antibodies, Microbiological, Serological, Biological and Nucleotide based diagnostic methods. Issues on bioterrorism.

23. VETERINARY PHARMACOLOGY

Unit 1: General Pharmacology: Development and Scope, branches of pharmacology, Terminology, Sources and nature of drugs. Pharmacopoeia and drug compendia. Drug Schedules. Factor modifying drug activity. Definition of pharmaco-genomics, polymorphism and its use in drug development.

Pharmacodynamics: Drug structure activity relationship. Drug receptor interaction. Role of secondary messengers. Drug modulation via different types of channels. Characterisation of agonist, antagonists.

Pharamacokinetics : Principles, Drug metabolism and biotransformation. Factors modifying drug kinetics. Kinetic constants. Different models, determination of kinetic parameters and application in rational dosage regimen.

Pharmacometrics: Organisation and screening programmes and drug development. Multidimentional screening methods, bioassays. Determination of median doses – $LD_{50,}$ $ED_{50,}$ therapeutic indices. Types of dose response relationship.

Unit 2: Drug Acting on Central Nervous System

Role of neurotransmitters in CNS. Sedatives, Hypnotics, General anaesthetics, Hypotheses and clinical stages of anaesthesia. Pre-and post-anesthetics, Molecular mechanism of action of inhalent and and parenteral anesthetics. Anticonvulsants. Tranquilizers. Narcotic and non-narcotic analgesics and antipyretics. Drugs affecting behaviour. Drug dependence and addiction and abuses. CNS stimulants. Muscle relaxants. Local anaesthetics.

Unit 3: Drugs Acting on Humoral and Autonomic Nervous Systems

Neurohumoral transmission. Adrenergic and antiadranergic drugs including adrenergic neuron blockers. Cholinergic and anticholinergic drugs. Purinergic and Adenosine receptors. Dopaminergic and antidopaminergic agents. Nitric oxide mediators. Neuromuscular and ganglion stimulants and ganglion blockers.

Unit 4: Drugs Acting on Cardio-vascular and Respiratory Systems

Drugs acting on heart and blood vessles. Antihypotensive and anti-arrhythnic agents. Blood coagulants and anti-coagulants. Heamatinics. Haemorrhagic shock and its treatment.

Expectorants, antiussives. Cough sedatives. Bronchodilators. Mucolytic agents. Analeptics.

Unit 5: Drugs Acting on Digestive System

Stomachics. Antacids. Carminatives and antizymotics. Emetics and antemetics. Cathartics. Anetidiarrhoeal agents. Antispasmodics. Pharmacology of rumen and rumenotoric drugs. Drugs acting on heapatobiliary system.

Unit 6: Drug action on Uro-genital System
Drugs altering fluid balance. Diuretics and antidiuretics. General principles of elecrolyte and therapy. Drugs acting on uterus (oxytocis and tocolytics). Therapy of infertility and improving conception and synchronization of oestrus

Unit 7: Endocrine Pharmacology
Mode of action and synthesis of pituitary hormones. Therapeutics of non-pituitary gonadotropin, adrenocorticoids, sex hormones, insulin, thyroid hormones, antithyroid agents, calcitonin, parathormone.

Unit 8: Autacoids
Pharmacological effects and therapeutics of histamine, antihistaminic agents, 5-HT its antagonists, prostaglandins and leukotrences, peptides and kinins, rennin and angiotensins. Platelet activators. Anti-inflammatory drugs.

Unit 9: Chemotherapy
General principles. Drug allergy, hypersensitivity, mechanism of resistance. Antiseptics and Disinfectants. Chemistry, mechanism of action, therapeutics of sulphonamides (gut active, systemic), thrimethoprim and congener.

Antibiotics: Penicillin, cephalosporins, aminoglycosides, macrolide, surface active, tetracyclines, polypeptide. Antifungal and other emerging antibiotics. Quinolones, nitrofurans, Antitubercular, antiviral and antineoplastic drugs.

Anthelminitic: Antinematodal, anticestodal, antitrematodal drugs. Antiprotonzoons, Anticoccdials. Drugs used for ectoparasite control.
Concept of Gene based therapy, prospects of disease target therapy, overview of indigenous medicinal drugs, its components for therapeutic use.

Unit 10: Toxicology:
Terminology. Classification of poisons. Toxicity rating. Principles of selective toxicity. Toxicodynamics. Toxicokinetics. Diagnosis and treatment of poisoning (anti-dotal and non anti-dotal). Mechanism of detoxification. Poisons causing respiratory insufficiency. Toxicology of common inorganic compounds. Toxicity of metals, non-metals and metalloids. Poisonous plant-cyanogenic, nitrate and oxalate producers. Mycotoxins : aflatoxin, rubratoxin, ergot. Toxic ferns. Venoms from snakes, scorpions, toads, etc. and treatment.

Unit 11: Ecotoxicology
Types and identification of industrial contamination and pollution residual toxicity. Impact of pesticides, fungicides, weedicides, fertilizers on biosphere. Chemical warfare agents and radiation hazards. Toxicity from food additives, preservatives. Statutory regulation on agrochemical formulation and their uses. Newer parameters, immunotoxicity, teratogenicity, mutagenicity, embroyotoxicity for toxicological evaluation.

Unit 12: Miscellaneous Topics:

Drugs promoting growth and production. Agents used for doping and restraining of wild animals. Euthanising agents. Drug control and regulation.

24. VETERINARY MICROBIOLOGY

Unit 1:General Bacteriology

Miestones in the development of microbiology, Classification and nomenclature of bacteria. Structure, function and chemistry of bacterial nuclear apparatus. Cytoplasm, Intracellular granules, Cell wal,. Cytoplasmic membrane, Mesosomes, Capsule, Flagella, Fimbrae, Endospore, Protoplasts, Spheroplasts, L-forms, Involution forms. Bacterial stains, staining and microscopy. Growth and nutritional requirements of bacteria. Bacterial enzymes. Respiration in bacteria. Carbohydrate protein, fat and nucleic acid metabolism in bacteria. Reproduction and growth phase of bacteria. Effects of chemical and physical agents and antibiotics. Bacterial variations including transduction, transformation and conjugation. Bacterial vaccines and toxins.

The role of microbial toxins in the pathogenesis of diseases; Biochemical and biological characteristics of toxins produced by various bacteria. Toxin producing Gram-positive and Gram-negative bacteria. Properties and clinical conditions produced by different bacterial toxins.

Unit 2: Systematic Bacteriology

Systematic study of bacteria belonging to genera Borrelia, Leptospira, Campylobacter, Pseudomonas, Brucella, Bordetella, Escherichia, Citrobacter, Salmonella, Shigella, Klebsiella, Enterobacter, Proteus, Vibrio, Haemophilus, Staphylococus, Streptococcus, Bacillus, Clostridium, Listeria, Erysipelothrix, Corynebacterium, Nocardia, Rickettsia, Chalmydia, Mycoplasma, Acholeplasma, Spiroplasma, Anaeroplasma and Thermoplasma, Rhodococcus, Mycobacterium and Neisseria.

Unit 3: General Virology

Historical development of virology. Evolution, classification and nomenclature of viruses. Biophysical and biochemical characteristics of viruses. Cultivation of viruses and their growth pattern in cell culture, embryonated eggs and experimental animals. Purification and concentration of viruses. Qualitative and quantitative assay of viruses. Viral replication. Virus-host cell relationships. Replication strategies of animal viruses and molecular pathogenesis for selected viral system. Latent, persistent and chronic virual infections. Study of genetic variability of animal viruses through use of monoclonal antibodies, autoimmunity, immunosuppression and viral mutation in persistence infections. General principles of laboratory diagnosis of viral diseases. Epidemiology and pathology of viral ifections. Immune mechanism in viral diseases. Interference and interferon. Viral vaccines, point of action of antiviral molecules during the replication cycle of a virus and search for new antiviral compounds, viruses and gene therapy. Chemotherapy of viral infections.

Unit 4:Systematic Virology

Systematic study of RNA and DNA viruses in livestock and poultry with reference to antigenicity, cultivation, pathogenesis, epidemiology, diagnosis and immunity, RNA viruses: Retroviruses and lymphotropic viruses, Visna and Maedi, Arboviruses, Rotaviruses. Birnaviruses. Picornaviruses. Bunyaviruses. Cornoaviruses. Togaviruses, Paramyxoviruses, Orthomyxoviruses, Rhabdoviruses. Picornaviruses. Bunyaviruses. Arenaviruses.

Arterioviruses. Calciviruses. Filovirsuses, DNA viruses: Poxviruses. Hepadnaviruses. Iridoviruses, Adenoviruses, Papovaviruses. Paravoviruses. Hepadanaviruses. Circoviruses. Unclassified viruses. Slow viruses Scrapie.

Unit 5: Mycology

General characterstics of fungi. Classification and study of pathogenic fungi-Epidermophyton, Microsporum, Trichophyton, Cryptococcus, Aspergillus, Blastomyces, Coccidioides, Histoplasma, Candida, Rhinosporidum, Contaminating fungi, Rhizopus, Mucor and Penicillium. Fungi causing mastitis, abortion and mycotoxicosis.

Unit 6: Immunology

Historical Perspectives. Host-parasite relationships. Antigens. Types of antigens. Properties and specificity of antigens. Factor determining antigenicity. Haptens and carriers. Heterophile antigens. Adjuvants. Mechanisms of action, classification and their uses. Immunoglobulins – their classes and sub-classes, structure and function. Allotypes. Idiotypes. Genes coding for Igs. Generation of diversity. Monoclonal antibodies. Purification of antibodies. Theories of antibody formation. Lymphoid organs: primary, secondary and circulation of lymphocytes, cells involved in the immune response – B lymphocytes, T lymphocytes, subsets and nature of receptors. Macrophages, Dendritic reticular cells, Langerhan's cells. Cellular interactions Cell-mediated immune responses. Mechanism of interaction of antigen and antibody. The complement system. Classical and alternate pa;thways. Serological reactions: agglutination, precipitation, neutralization, CFT, FAT, ELISA, DIE, RIA, etc, Immunological methods as an aid to diagnosis, blotting techniques like Northern, Western blotting, Major, Histocompatibility complex: organization.

Nature of antigens and MHC restriction. Hypersensitivity – immediate and delayed types, and mechanism of hypersensitivity. Mechanism of immunity, autoimmunity and immunological tolerance.

Unit 7: Molecular Cell Biology (Vaccine & Diagnostic Technology)

Role of biotechnology in diagnostics and vaccines, RNA electropherotyping. Probes - preparation of cDNA. Use of DNA probe in animal diseases diagnosis. Monoclonal antibodies. Application on monoclonal antibodies for diagnosis of animal diseases. Preparation of monoclonal antibodies. Nucleic acid hybridization. Modern trends in vaccines. Recombinant DNA vaccines and their probable use in animal diseases. Bioinformatic tools in microbial research, Biosafety, Biosecurity, GMP and GLP.

25. ANIMAL REPRODUCTION AND GYNAECOLOGY

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Unit 1: Veterinary Gynaecology

Biology of sex. Development of female genitalia. Functional anatomy of female reproductive system of farm animals. Growth, puberty and sexual maturity. Reproductive cycles (oestrous cycle) in female farm animals. Oogenesis and folliculogenesis. Follicular dynamics and ovulation. Transport and survival of gametes, fertilization, cleavage, implantation and maternal recognition of pregnancy. Development of foetus and foetal membranes. Placenta-classification and functions. Gestation and pregnancy diagnosis in farm animals.

Unit 2 : Reproductive Endocrinology

Reproductive hormones, classification, synthesis, chemical composition and mechanism of action. Hypothalamus, pituitary, thyroid, gonadotropic, gonadal, placental and pineal gland hormones. Prostaglandins, pheromones, growth factors and hormone antagonists and their significance in animal reproduction. Hormonal assays. Hormonal regulation of male and female reproduction. Clinical uses of hormones.

Unit 3 : Accidents during Gestation

Pregnancy, Pseudocyesis, Ectopic pregnancy, Abnormalities of fertilization and foetal development, Superfecundation and superfetation. Abortion – bacterial, viral, mycotic, protozoal, physical, toxic and miscellaneous causes, diagnosis and prevention, Dropsy of foetal membrane and foetus, Maceration, mummification, Pyometra, Antepartum vagino-cervical prolapse, Uterine torsion and displacement of uterus.

Unit 4 : Veterinary Obstetrics

Pelvis and pelvimetry. Parturition – Signs approaching parturition, initiation and stages of parturition, induction of parturition and postpartum period. Presentation, position and posture. Causes and forms of dystocia and its treatment. Epidural anaestheia. Obstetrical maneuvers including fetotomy and Caesarean section. Post-partum complications in domestic animals, retention of placenta, uterine proplapse, endometritis, metritis, septic metritis. Post parturient metabolic disorders.

Unit 5 : Andrology

Comparative anatomy of male reproductive system. Thermoregulation of testis and blood testis barrier, Growth, puberty and sexual maturity. Spermatogenesis including cycle of somniferous epithelium and spermatogenic wave. Sperm morphology and ultra-structure of spermatozoa, sperm transport, maturation and storage in male genital tract, Secretions of male reproductive tract including accessory glands and their role in reproduction, Sexual / mating behaviour. Semen and its composition, biochemistry of semen and sperm metabolism, sperm abnormalities and its classification, sperm separation and spermatozoa karyotyping.

Unit 6 : Male Infertility

Fertility, infertility and sterility in male domestic animals. Causes and forms of male infertility. Testicular hypoplasia, cryptorchid, testicular degeneration, orchitis, affections of epididymis, vas deference, penis, prepuce and accessory glands & their management, tumors of the male reproductive tract, nutritional infertility, Vices in the males.

Evaluation of male for breeding soundness, reproductive health status. Effect of parental drugs and vaccines on semen quality.

Unit 7 : Frozen Semen Technology and Artificial Insemination

History and development of artificial insemination. Advantages and disadvantages of AI and frozen semen, selection of bulls for AI purpose. Management of breeding bulls, methods of semen collection in different domestic animals, semen evaluation including latest techniques for evaluation of motility and fertilization.

Ideal extenders, extenders for liquid semen. Preservation of semen at various temperatures. Processing and preservation of liquid semen. Extenders for frozen semen, principles and techniques of semen freezing. Cold shock and ultra-low temperature shock. Cryoprotectants. Semen additives. Evaluation of frozen semen. Transport and storage semen. Handling of frozen semen, Liquid nitrogen and its containers. Insemination techniques. Planning and organization of semen bank.

Unit 8 : Reproductive Technology

Synchronization of oestrous cycle in domestic animals, control of ovulation. Embryo transfer technology – History, advantages and disadvantages, superovulation, collection, evaluation, preservation and transfer of oocytes / embryos.

History of *in vitro* maturation and fertilization. Recovery of oocytes *in vitro* and *in vivo*, maturation, fertilization, culture, evaluation, preservation and transfer of oocytes / embryos. Micromanipulation of embryos. Embryo splitting and cloning. Stem cells and production of transgenic animals. Sex determination and gene insertion. Establishment of laboratory for ETT, IVM, IVF and IVC.

Use of Ultrasonography, laparoscopy and ovum-pick technology in farm animals.

Unit 9 : Infertility in Cows and Buffaloes

Fertility, infertility and sterility. Evaluation of herd fertility. Incidence and economic role of infertility, forms of infertility, congenital and hereditary defects, infectious diseases. Pathological conditions of ovary, oviduct, uterus, cervix and vulva. Management causes of infertility. Hormonal causes of infertility, anestrus, repeat breeding, cystic ovarian degeneration, sexual health control and reproductive health programmes. Breeding soundness examination of cows and buffaloes.

Unit 10 : Reproduction and Infertility in Ovine / Caprine

Puberty, sexual maturity, breeding season, oestrous cycle, Breeding and conception, gestation, parturition, peri-parturient and obstetrical complications. Synchronization of oestrous cycle. Embryo transfer. Causes of infertility and their management.

Unit 11 : Reproduction and Infertility in Swine

Estrous cycle, synchronication of oestrous cycle, Hormonal control of reproduction. Various forms of infertility in swine and their management. Various obstetrical problems and their management.

Unit 12 : Equine Reproduction

Physiology and pathology of equine reproduction. Research techniques and methodology for the study of equine reproduction. Equine andrology. Reproductive behaviour and management of stallion. Semen collection, examination and artificial insemination. Pregnant mare behaviour . Application of modern reproductive techniques in equine reproduction. Equine infertility.

Unit 13 : Canine and Feline Reproduction

Functional anatomy of dog and cat reproductive system, oestrous cycle and endocrinology of oestrous cycle and detection of optimum breeding time. Exfoliative vaginal cytology. Methods of pregnancy diagnosis, contraception. Medical termination of pregnancy. Infertility in bitches, disorders of oestrous cycle, psedopregnancy, pyometra, cystic endoretrial hyperplasia, tumors of reproductive tract. Difficult whelping – types and methods of handling dystocia. Caesarean section. Ovarian hysterectomy. Peri-partutrient complications. Semen collection, evaluation, techniques of artificial insemination, infertility in male including testicular tumors – cryptorchid, affections of prostate.

26. VETERINARY MEDICINE

Unit 1: General Medicine

Epidemiology and its ingredients. Definitions of diseases known as – infectious, contagious, sporadic, epizootic, enzootic, panzootic, exotic, zoontic, etc. Meaning and purpose of segregation, isolation, quarantine, etc., role of occurrence, prevalence, incidence, morbidity rate, mortality rate, case fatality rate, mode of transmission, vectors, spread, economics, etc. in terms of epidemiology of diseases. General systemic states like – bacteremia, septicemia, pyemia, toxemia, hyperthermia, hypoglycemia, allergy, anaphylaxis, shock, dehydration, stress, sudden death, anasarca, anaemia, pica, etc.

Unit 2: Diagnosis of Animal Diseases

History taking. General clinical examination. Special clinical examination – electrocardiography, paracentesis, rumen fluid examination, haematology, blood biochemistry, urinalysis, ophthamosocopy, otoscopy, endoscopy, ultrasounography, biopsies, etc.

Unit 3: Gastroenterology

Specific conditions of organs of gastrointestinal system with special emphasis to – simple / acid / alkaline indigestion, GI ulcers, choke, tympany, colic, impaction, traumatic reticulitis / peritonitis, abomasal displacement, ascites, jaundice, hepatitis, enteritis, gastritis, etc.

Unit 4: Diseases of Cardiovascular and Pulmonary System

Principles of circulatory failure, Acute heart failure, Congestive heart failure, Perpheral circulatory failure. Mycocardial and valuvalar diseases. Epistaxis. Pulmonary congestion and oedema. Emphysema. Pneumonia. Pleurisy, URI Aspiration pneumonia.

Unit 5: Diseases of Urinary, Nervous, Musculoskeletal and Integumentary Systems

Nephrosis, Nephritis. Pyelonephritis. Cystitis. Urolithiasis. Uremia. Cerebral anoxia. Encephalitis. Encephalomalacia. Meningitis. Encephalomyelitis. Paralysis. Urticaria. Dermatitis. Photosensitisation. Seborrhoea. Conjunctivitis. Otitis. Kerato-conjunctivitis. Corneal ulcerns. Eczema. Impetigo. Alopecia.

Unit 6 : Production and Deficiency Diseases

Metabolic profile test, milk fever, Downer's cow syndrome, ketosis, hypomagnesaemia, diabetic ketoacidosis, hypomagnesaemia, post-parturient haemoglbinuria, azoturia. Fat cow synodrome, rickets, osteomalacia, osteodystropinafibrosa. Trace mineral and vitamin deficiency.

Unit 7 : Common toxicities

Sources, pathogenesis, clinical manifestations, post-mortem findings, diagnosis and treatment of conditions occurring in the following classes of poisonings: Metal Corrosives / irritants. Plant poisonings. Water-borne toxicities. Pesticide poisonings. Insect bites and stings. Snake bite. Environmental pollution hazards. Radiation hazards and injuries.

Unit 8 : Infectious Diseases (Bacterial and Mycoplasmal)
Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of livestock : Mastitis, Strangles. Caseous lymphadenitis in sheep and goats. Clostridial diseases. Ulcerative lymphangitis in horses & cattle. Listeriosis, Leptospirosis, Erysipelas, Collibacillosis, Salmonellosis, Pasteruellosis, Brucellosis, TB, JD, Actinomycosis, Actinobacillosis, Glanders, and Mycoplasmal diseases.

Unit 9 : Infectious Diseases (Virtal, Chamydial, Rickettsial and Fungal)
Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of livestock: Hog cholera. African swine fever. Leucosis FMD, RP. PPR. BMC BSE. Bovine viral diarrhoera. Muscoal diseases. Bluetongue. Influenza. Maedi. Pulmonary adenomatosis. Rabies. Encephalomyelitis. Pseudorabies. Louping ill. Caprine arthritis, encephalitis, Scrapie, Visna, Contagious ecthyma. Pox, Papillomatosis, Distemper. Infectious canine hepatitis. Parvo virus enteritis. Feline panleucopenia. Anaplasmosis, Heart water diseases, Contagious opthalmia., Aspergillosis, Ring worm, Bursattee, Lymphangitis, Babesiosis, Theileriosis, Coccidiosis, Trypanosomosis, Toxoplasmosis.

Unit 10: Parasitic Diseases
Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of livestock: Major conditions produced by nematode, cestode and trematode infestations. Major conditions produced by arthropod parasites.

Unit 11: Poultry Diseases
Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of poultry: Newcastle disease, IBD, ILT, mycoplasmosis, coccidiosis, salmonellosis, necrotic enteritis, malabsorption. leucosis. Mareck' disease, mycotoxicosis, avian encephalomyelitis. hydropericardium syndrome. avian influenza, psittiacosis-ornithosis, TB, histomonosis,spirochaetosis, trichomonosis, etc., parasitic diseases of poultry.

Unit 12: Veterinary Jurisprudence and Ethics
Judicial procedure. Duties of veterinarian particularly as an expert evidence. Vetro-legal aspects of wounds. Vetero-legal aspect of death in general, due to diseases, drowning, near drowing, electrocution, lightening, etc. Post-mortem examination of a vetro-legal, cases. Collection and dispatch of materials for forensic science examiniation. Common offense against animals. Common frauds in dealing with livestock and livestock products. Animal Insurance. Identification of animal species for vetero-legal purposes. Determination of time since death. Examination of blood and semen stains. Blood grouping in animals and its vetero-legal significance. Veterinary ethics: Code of conduct, professional ethics and etiquette for veterinarian. Laws: Role of veterinarian. Legal enactment in IPC related to animals and veterinarians. Prevention of Cruelty to Animal Act, Indian Veterinary Council Act. Wild life (protection) Act. Glanders and Farcy Act, Livestock Importation Act. Dangerous Drug Act and Prisoning Act. Legal provisions related to animals, animal diseases and drugs.

Unit 13: Special therapeutic Approaches

Veterinary fluid therapy with fluid, electrolyte, plasma expanders, packed cell transfusions, etc. Clinical assessment of their requirement and doses. Blood transfusion with blood groups in animals-their therapeutic significance. Blood matching methods. Oxygen therapy.

Unit 14: Prevention and Control of Diseases

General principles of control of diseases. Role of OIE in disease control. Internationally recongnised control methods of designated diseases. Prevention and control methods for national, area and herd based control programmes of diseases like TB, JD, rabies, brucellosis, HS, anthrax, BQ, mastitis, FMD, bluetongue, etc.

Unit 15: Common Diseases of Zoo, Laboratory Animals and Wildlife

Clinical signs, diagnosis and treatment of diseases of wildlife and zoo animals: Shock, stress, diseases of cardiovascular system, capture myopathy, metabolic and nutritional diseases, toxicosis by chemicals and plants, tuberculosis, paratuberculosis, pasteurellosis, anthrax, rabies, FMD, RP, Kyasanur forest diseases (KFD), surra, helminthiasis. Clinical symptoms, diagnosis and treatment of diseases of laboratory animals: Tyzzer's diseases, salmonellosis, pasteurellosis, strepto and staphylococcosis, psedudomoniasis, corynibacteriosis, mycoplasmosis (MRM), herpesvirus infection, pox diseases, coccidiosis, toxoplasmosis, giardiasis, helminthic infection, dermatophytosis, scabies, dermatitis, metabolic and nutritional deficiencies. Management related diseases of mice, rat, guinen pig, hamster and rabbit.

27. VETERINARY SURGERY

Unit 1 : General Surgery

Cureent concepts of inflammation and its management. Asepsis and antisepsis in surgery. Disinfection and sterilization. Surgical bacteriology. Pre-, Peri and post-operative considerations. Physiopathology of burns, tauma, surgical stress and shock. Haemorrhage, haemostasis and administration of whole blood, blood extracts and plasma substitute. Acid – base and electrolytes imbalance. Rehydration and fluid therapy. Tissue repair including its biochemical aspects. Principles of tissue and organ transplantation. Tissue transplantation immunity. Sutures and suture materials. Operation theatre management. General surgical affections viz.. abscess, cyst, haematoma, tumour, gangrene, sinus, fistula and hernia. Neurological examination, paralysis and its treatment. Surgical instrumentations. Care of critically ill patients. Cosmetic surgery. Skin grafting techniques in animals.

Unit 2 : Anaesthesia

History and instrumentation. Pre-anaesthetic considerations of patient. Selection of various anaesthetic and pre-anaesthetic agents and their effects on different body organs. Inhalant and non-inhalant anaesthetic agents including dissociative, neurolept and balanced anaesthesia and their administration in small and large animals. Monitoring of patient during anaesthesia. Anaesthetic emergencies and their management. Muscle relaxants. Local anaesthetic agents. Local and regional anaesthetic procedures. Anaesthesia for special surgical procedures and special disease conditions. Electronarcosis. Hypothermia. Acupuncture analgesia. Anaethesia and methods of capture of zoo animals. Therapeutic usage of local anaesthetic agents and techniques. Methods of artificial ventilation.

Unit 3 : Radiology

Production and quality of X-rays; exposure factors and formulation of technique chart. Basics of radiation physics. Interaction of particulate and non-particulate radiations with matter. Radiographic artifacts and their prevention. Radiographic quality and factors affecting it. Radiographic features of diseases of musculo-skeletal, digestive, urogenital, cardiovascular, respiratory and lymphatic system of small and large animals. Radiation hazards. Radiation biology including its mechanism of action and effects on various organ systems. Radiation protection. Radiological contrast agents and common contrast radiographic procedures. Principles of radiotherapy and physiotherapy. Invasive and non-invasive imaging modalities viz. echocardiography, computed tomography, scintigraphy, magnetic resonance imaging, ultrasonography and substraction angiography.

Unit 4 : Orthopaedics and Lameness

Physiological and biochemical considerations of bone. Osteogenesis and mineralization of bone. Bone research techniques. Circulation of long bones. Biomechanics of fractures. Etiology, classification and healing of fracture; factors affecting fracture healing. Complications of fractures and their management. Methods of internal and external fixations of fracture and factors governing selection of fixation methods. Effect of various internal fixation methods on physiology and blood circulation of bone. Bone grafts. Metallic and non-metallic materials in

bone surgery and their biological behaviour. Surgical affection of vertebral column. Etiology, pathophysiology, diagnosis and treatment of affections of bones and joints. Technique of arthroscopy. Lameness and allied surgical conditions of fore and hind limbs. Various foot diseases. Affections of tendons, ligaments and their management. Relationship between conformation of the limbs, foot and its axis to soundness. Soundness and examination of horse for soundness.

Unit 5 : Surgery of Head and Neck Region

Etiology, diagnosis and surgical management of the affections of sinuses, horn, nasal and buccal cavity, teeth, tongue, salivary glands, larynx, pharynx, trachea and oesophagus. Surgical affections of eye lids, lacrimal apparatus, nictitating membrane, conjunctiva, cornea, sclera, chloroids, iris, retina, lens, optic nerve, aqueous and vitreous humours and other parts of eye and their management. Surgical affections and management of ear and guttural pouch.

Unit 6 : Thoracic Surgery

Various approaches for thoracic surgery in large and small animals. Physiological alterations following thoracotomy. Heart lung machine and its use in thoracic surgery. Different congenital and acquired surgical affections of thoracic wall and thoracic organs viz. lung, mediastinum, oesophagus, heart and diaphragm in large and small animals. Surgical diseases of the vascular and lymphatic systems.

Unit 7 : Abdominal and Pelvic Surgery

Different surgical approaches for abdomen. Hemia: etiology, pathophysiology and treatment. Various acquired and congenital surgical affections of abdominal organs viz. Traumatic reticulitis, abdomasal displacement, impaction of omasum, pyloricstenosis, gastric torsion, caecal dilation, intestinal obstruction, rectal and anal prolapse, and peritonitis. Colic in horse:- etiology, diagnosis and treatment. Affection of liver, spleen, kidney and urinary bladder their complications and surgical management. Urolithiasis, uraemia and their management. Surgery of male and female gential organs. Etiology, diagnosis and surgical management of the affections of udder, teat and tail.

28. ANIMAL NUTRITION

Unit 1: Energy and Proteins:
Nutritional significance of carbohydrates, lipids and proteins. Cell-wall fractionation. Available energy from organic nutrients. Partitioning of dietary energy. Basal metabolic rate. Energy retention. Factors affecting energy utilization. Direct and indirect calorimetry. Dietary lipids - their digestion, absorption and metabolism. Essential fatty acids. Effect of dietary fat on milk and body composition. Proteins - digestion, absorption and utilization. Comparative efficiency of amino acids as energy source. Essential and critical amino acids. Protein evaluation. Metabolizable protein concept. Protein energy inter-relationship. Energetic of protein utilization for maintenance and different productive functions.

Unit 2: Minerals, Vitamins and Feed Additives
Minerals: Classification of minerals, Physiological functions, Deficiency symptoms and toxicity - Inter-relationships - Synergism and antagonism - Requirements - Different sources and bio-availability - Role of chelated minerals. Vitamins: Physiological functions and co-enzyme role - Deficiency symptoms, hyper-vitaminosis. Requirements, Sources and vitamin analogues - Antivitamins – Feed Additives: Nutritional role. Prebiotics - Probiotics, phytochemicals other metabolic modifiers. Role of phyto-chemicals as growth promoters.

Unit 3: Rumen eco-system and functions
Rumen and its environment. Development of functional rumen. Digestion kinetics in reticulo-rumen. Role of rumen microbes, Significance of rumen fungi- Defaunation and transfaunation. Microbial fermentation in rumen. VFA production, inter-conversion and utilization. Dietary protein breakdown. Microbial protein synthesis. NPN compounds and their utilization. Ammonia toxicity - Role of slow release urea compounds. Manipulation of rumen fermentation. Bio-hydrogenation and utilization of dietary lipids. Methanogenesis and methane inhibitors.

Unit 4: Non-ruminant Nutrition
Comparative gastrointestinal physiology of monogastrics – digestion and metabolism of organic nutrients in poultry and swine. Significance of minerals and vitamins in mono-gastrics. Inter relationship in nutrient sparing activity. Feeding systems. Role of feed additives - Factors affecting nutritional quality and performance. Special nutritional needs of rabbits, horses and companion animals.

Unit 5: Nutrient Requirements
Energy protein requirements for maintenance and productivity in ruminants and non-ruminants. Colostrum feeding of calf, mineral and vitamin requirements. Dry matter intake in relation to productivity. DM: water intake ratio. Palatability. Nutritional intake and energy density. Feeding standards - NRC, ARC, Kearl and Indian. Nutrient requirements under temperate and tropical environment. Feeding strategies during stress and natural calamities - Ration formulation - least cost rations.

Unit 6: Forage Conservation and Evaluation

Natural and cultivated forges-Their composition and nutritive values. Nutritive value Index. Forage quality evaluation in range animals -Role of indicator methods-Advances in silage and haymaking- Factors affecting quality of conserved forages- Quality criteria and grading of silage and hay under tropics-artificial drying of forages.

Unit 7: Feed Processing and Technology

Methods of feed processing - physical, chemical and biological effect of processing on nutritional quality and utilization. Pelleted and extruded feeds. Quality control of raw feedstuffs and finished feeds: Significance of BIS (standards). Handling and storage of raw and finished feeds. Methods to improve shelf life of fat rich feeds, By-products of newly introduced commercial crops including residues of genetically modified feeds. Alternative feed resources. Current approaches in enriching tropical feed resources - concept of total mixed ration and advances in complete diet formulation.

Unit 8: Anti-metabolites and Toxic Principles

Naturally occurring anti-nutritional factors and common toxins in feeds and forages. Methods of detoxification. Health hazards due to residual pesticides in feeds and forages - Environmental pollutants.

Unit 9: Elements of Research Methodology

Principles of animal experimentation - Experimental designs in nutritional research. Modern methods of feed evaluation – *In vitro*, gas production and nylon bag techniques, Rumen simulation techniques - Rusitec Tracer techniques in nutrition research - Role of NIR Spectroscopy - Feed microscopy in quality evaluation of feedstuffs.

Unit 10: Clinical Nutrition

Role of nutrition to control digestive and metabolic disorders (milk fever, ketosis, ruminal acidosis-laminitis, bloat), metabolic profile tests. Role of nutrition in immunity, nutrition and reproduction, nutrients as antioxidants. Role of nutrition in management of GI parasites.

29. ANIMAL GENETICS AND BREEDING

Unit 1 : Overview of Genetics

History and development of genetics. Classic researches and pioneer scientists in genetics. Mendalism and its deviations. Chromosomes and heredity. Sex in relation to chromosomes and genes. Linkage and crossing over. Artificial transmutation of genes. Penetrance and expressivity. Multiple factor inheritance. Gene modifiers. Non-chromosomal genes and their inheritance, Chromosomal aberrations. Mosaicism and chimerism.

Unit 2 : Advanced Genetics

Fine structure of chromosomes and chromosomal banding. Gene and mechanism of gene action. DNA replication. Central dogma. Protein synthesis. Genetic code and DNA cloning. Recombinant DNA technology. PCR. Gene banks. Split gene. Genetic control of hormone coordination, metabolism and metabolic diseases. Use of biotechnological tools in improving animal productivity. Application of immunogenetics. Biochemical polymorphism. Chromosomal studies in livestock improvement programmes. Development of clones in relation to animal productivity and maintaining biodiversity. Production of transgenic animals. Gene mixing for useful functions.

Unit 3 : Overview of Breeding

Brief history of domestication of livestock. Important breeds of livestock & poultry with special reference to economic characters. Evolution of genetic systems. Isolating mechanisms and origin of species / sub-species, their adaptation. Mating systems for different livestock and poultry. Genetic and phenotypic consequences and applications of inbreeding and out-breeding. Genetic basis of heterosis and its use. Diallele and polyallele crossing. Reciprocal and reciprocal-recurrent-selection. Combining ability. Developments in population and production of livestock and poultry in India. Status of Animal Genetic Resources in India.

Unit 4 : Genetic Properties of Population

Population Vs individual. Inheritance and continuity of population. Effective population size. Biodiversity. Description of animal population. Value and means; Average effect of gene and gene substitution. Components of total phenotypic variance of a population. Resemblances between relatives. Concept of heritability, repeatability; & phenotypic, genetic and environmental correlations. Methods of estimation, uses, possible biases and precision of estimates.

Unit 5 : Population Genetics

Gene and genotypic frequencies and factors affecting them. Hardy Weinberg Law and consequences of it. Prediction of selection response by different methods. Selection for threshold characters. Indirect selection and correleated response. Theoretical basis of change of population mean and variance on inbreeding and cross breeding. Genotype – environment interaction. Metric characters under natural selection. Quantititive trait loci and their applications. Marker-assisted selection.

Unit 6 : Genetic Stretegies

Purpose-wise breeding strategies for livestock and poultry under different agro-climatic zones of India. Evaluation of past genetic improvement programmes for livestock and poultry in India. Bottlenecks in implementation of livestock breeding programmes in India. Evaluation and characterization of various indigenous breeds of livestock and poultry. *Ex-situ* and *In-situ* conservation of animal and poultry genetic resources. Development of new breeds / strains for better productivity in animals. Open nucleus breeding system in livestock improvement in India. Bio-technology and its role in improving animals and poultry production. Role of artificial insemination / frozen semen / embryo transfer / ONBS / MOET technology in animal breeding. Fromulation of breeding programmes : Purpose-wise, breed-wise, region-wise for different species of livestock and poultry. Programmes for genetic improvement of non-descript livestock population of different species. Evaluation and current recommendations of cross breeding programmes of cattle, sheep and goat in India.

Unit 7 : Selection & Selection Experiments

Basis and methods of selection. Construction of selection indices. Different methods of sire evaluation. Selection differential and intensity of selection. Prediction of response. Improvement of response. Effect of selection on variance. Realised heritability. Long-term and short-term objectives of selections. Selection experiments in livestock and poultry. Role of control population in selection experiments. Selection for disease resistance and development of general and specific disease resistant strains / breeds. Purpose based selection and breeding of domestic animals and poultry. Genetic-slippage. Estimation of genetic divergence and its implications in livestock improvement programmes. Selection for better feed conversion efficiency in meat animals and poultry.

Unit 8 : Genetic Laboratory Techniques

Culturing *Drosophila* stock. Study of *Drosophila* with markers. Gene sequencing. Blood group typing. Karyotyping and chromosomal mapping. Concept of recombinant DNA techniques cloning and gene mapping. Nuclic acid hybridization. Development of breed descriptors at molecular level for different livestock and poultry breeds. Biochemical polymorphism analyses – blood groups, transferrins, milk proteins. Collection and storage of samples for DNA fingerprinting; isolation and quantification of DNA from blood and semen; Restricted enzyme digestion of genome DNA, Analysis and transfer of DNA from agarose electrophoresis; Nucleic acid hybridization; Analysis of DNA fingerprinting, PCR-RFLP assay. Cryogenic preservation of animal germplasm.

Unit 9 : Research Techniques for Quantitative Animal Genetics

Use of computers in handling animal breeding data. Estimation of variances and covariances. Development of statistical models for analyses of breed data and to quantify environmental variance. Estimation of inbreeding and relationship. Estimation of inbreeding rate in a closed herd / flock. Estimation and interpretation of genetic and phenotypic parameters. Development of efficient selection programmes and procedures. Estimation of genetic gains. Designing and evaluation of breeding strategies like reciprocal recurrent selection, diallele and polyallele crossing. Designing field based progeny testing programmes. Development of efficient methods and traits for genetic evaluation of males under indigenous conditions. Data bank concept.

Unit 10 : Laboratory Animal Breeding

Laboratory animal species *viz* mice, rat, guinea pig, rabbit, dog and monkey – Their chromosome numbers – genome size – major genes. Physiological, nutritional, reproduction parameters, maintenance protocol – pedigree recording, planned mating. Selection and Mating methods /systems- monogamous, polygamous and others. Genetic control and monitoring-Record keeping-Ethics and legislation for management and use of laboratory animals. Nomenclature for different strains, inbred lines (SPF line, Knockout mice, etc.) – Animal model for human disease. Specific utility of different laboratory species for different requirements.

30. LIVESTOCK PRODUCTS TECHNOLOGY

Unit 1: Basic and General Aspects of Livestock Products

Composition and physico-chemical properties of cow and buffalo milk. Milk proteins, lipids, carbohydrates, minerals, vitamins and other minor constituents of milk. Nutritive value of milk. Reception of milk - platform tests, filtration and clarification, chilling, separation, standardization, pasteurization and homogenization. Cleaning and sanitation of dairy equipments.

Present status and future prospects of meat and poultry industry. Structure, composition, physical biochemical and nutritive aspects, and functional properties of different kinds of meat, fish, poultry and eggs. Sensory evaluation and organoleptic properties of livestock products. Postmortem aspects of muscle as meat. Ageing of meat and chemical changes. Meat in human health. Bacteria, yeasts,l molds, parasites important in food microbiology. General principles of spoilage. Chemical and deteriorative changes caused by micro-organisms. Contamination and spoilage of meat, fish, poultry and eggs. Food poisoning and foo-borne infections. Assessment of microbial condition and wholesomeness of different livestock products. National and International microbial standards.

Unit 2: Abattoir and Poultry Processing Plants

Origin and source of animal foods. Lay out, construction, design, organization, operation and maintenance of abattoirs and poultry processing plants. Pre-slaughter care and slaughtering techniques for different animals and birds. Antemortem and postmortem inspection. Judging and grading of animals and birds on foot and on rail. Condemnation and disposal of unfit material. Disposal of slaughterhouse effluents. Sanitation, plant operation and maintenance. Sanitary standards for meat packing plants. Meat cutting and deboning. Adulteration and misrepresentation of meat. State, municipal and other regulations pertaining to meat trade. Meat food products order. Processing and utilization of various animal and poultry by-products, slaughterhouse and poultry plant offals. Methods of utilization of blood, fat, hides and skin, horns, hooves, wool, hair, feather, glands and other by-products. Importance and utilization of by-products in industry, Application of computer science in abattoir operation. Robot technology and its application in meat and poultry industry.

Unit 3: Processing and preservation

Principles of processing of dairy products. Special milk: sterilized milk, flavoured milk, homogenized milk, soft curd milk, Vitaminized/irradiated milk, fermented milk, standardized milk, reconstituted/rehydrated milk, recombined milk, toned, double toned milk, skimmed milk, Humanizd milk. Processing of dairy products: - butter, butter oil, icecream, cheese, cream, condensed milk, dried milk, dried milk products etc. Indigenous dairy products: ghee, khoa, dahi, makkhan, chhana, paneer, Khurchan, Lassi, Organic milk.

Principles of preservation of livestock products. Equipment and technology of processing and preservation. Industrial food preservation, chilling, freezing, freeze drying, dehydration, canning irradiation, pasteurization, curing, smoking, use of chemical additives and antibiotics. Cooking methods including micro-wave cooking. Tenderisation and use of enzymes for processed foods. Production of value added products, process methods, process optimization and quality control.

Development and preservation self stable (camed and dehydrated) intermediate moisture, textured, cured, fermented fabricated meat and poultry products. Sanitation, regulation and inspection of processed meat foods. Effect of processing on nutritional, chemical, microbiological and organoleptic qualities of livestock products. Economics of precosting and product development. Application of biotechnology in processing and preservation of meat, poultry and fish products. Bioactive products and biogenic amines.

Unit 4: Wool, Mohair and Fur

Basic aspects of wool science. Shearing, physical and chemical characteristics, processing, grading, standardization, storage and marketing of wool, mohair and fur (National and International).

Unit 5: Packaging

Principles of packaging. Types of packaging materials. Characterisation, methods and systems of packaging. Gas packing, Vacuum packing, modified atmosphere packing, shrink and stretch packing, industrial packaging. Aseptic and retort pouches. Standardisation and quality control of packaging material. Product attributes and packaging requirements for different livestock products. Latest trends in packaging of meat, poultry, eggs, wool and fish products.

Unit 6: Quality Control

Grades and grading of livestock products. Stress factors effecting meat quality – PSE, DFD, Hot boning, Cold shortening and electrical stimulation. Regulatory and inspection methods – Municipal and State laws. Bureau of Indian Standards and International Standards of fresh meat and poultry including their products and by-products. Detection of antibiotics, chemical residues, heavy metals and toxins in meat. Techniques for detection of adulteration of meat. HACCP concept of quality control of meat, fish, poultry and eggs.

Unit 7: Marketing

Livestock production and supply characteristics. Meat consumption and related demands. Types of market and trends in marketing livestock products and by-products, wholesale, retail and future trends. Consumer aptitude, education and awareness, and popularization of new products. Corporate bodies in regulation of markets, marketing boards, Co-operative agencies, internal trade and development of international market for livestock products. Organization, operation and sanitation of meat, poultry, fish and egg retailing units. Fast food chains and super markets. Situation and outlook and methods for promotion and marketing of livestock products.

31. LIVESTOCK PRODUCTION AND MANAGEMENT

Unit 1: General

Present status and future prospects of livestock and poultry development in India. Animal production systems in different agro-climatic zones of the country. Sustainability issue in relation to environment. Effect of industrialization and mechanization of agriculture on livestock sector. Breeds of cattle, buffalo, sheep, goat, pigs, equine, camels, rabbits and poultry. Various livestock and poultry development programmes operative in the country. Animal behaviour vis-à-vis adaptation and production. Principles of domestication and behavioral factors favouring domestication. Mating bahviour in various species of livestock and poultry. Agnostic behaviour – causes and control. Social order in farm animals. Adaptation of livestock and poultry in tropics, deserts cold and high altitudes. Mixed farming, arable farming, integrated and specialized farming systems. Biotechnology in animal improvement.

Unit 2: Breeding Management

Basic principles of inheritance. Concept of heritability, repeatability and selection. Important methods of selection and systems of breeding in farm animals and birds. Importance of maintaining breeding records and their scientific interpretation.

Unit 3: Feeding Management

Nutrients and their functions. Nutritional requirements and feeding managements of different categories of livestock and poultry. Feed additives including antibiotic and probiotic feeding in farm animals and birds. Formulation and compounding of rations for various categories of livestock and poultry. Least cost ration formulation. Systems of feeding livestock and birds. Feeding standards for livestock and poultry. Feed conversion efficiency of various categories of livestock and poultry. Processing and storage of conventional and non-conventional feed ingredients. Agro-industrial by-products in animal feeds.

Unit 4: Reproduction Management

Reproductive systems of farm animals and birds. Climate and nutrition affecting reproductive performance in farm animals. Importance of early pregnancy diagnosis. Methods of heat detection. Artificial insemination. Oestrous prediction and synchronization. Causes of disturbed fertility and its prevention in farm animals. Management factors affecting reproductive efficiency. Summer and winter management problems and their solutions.

Unit 5: Shelter Management

Housing systems, Selection of site and lay out of animal and poultry houses. Space requirement for livestock and poultry, Housing designs in different agro-climatic regions. Macro and micro-climatic changes affecting designs of animal and poultry houses. BIS (standards) for livestock and poultry housing. Construction of cheap animal and poultry housing utilizing local resources. Automation in livestock farming. Disposal of animal wastes under urban and rural conditions. Disposal of carcasses.

Unit 6: Health Management

General approach to livestock health programmes. Prevention of diseases. Hygiene and sanitation on animal farm. Symptoms of ill health, important infectious diseases of livestock and poultry and their control. Vaccination schedules in animals and poultry. Internal and external parasites and their control. Accidental health disorders and their control. Common disinfectants used on animal farms. Concept of first aid at farms. Segregation and quarantine management for large animals and birds. Quarantine Act, Zoonotic diseases, labour health programme.

Unit 7: Production and Management of Cattle and Buffalo

Cattle and buffalo production trends and factors affecting them. Prenatal and postnatal care and management of cattle and buffalo. Care of neonates and young calves. Management strategies for reducing mortality in caalves, age at first calving, and calving intervals. Management to improve reproductive efficiency in cattle and buffalo. Feed conversion efficiency for growth and milk production. Water requirement of dairy animals. Herd registration.

Unit 8: Production and Management of other Animals

Draft animals: Population dynamics of various categories of draft and work animals in India. Characteristics of draft animals. Estimating draft capacity of different species. Harness for various types of draft animals. Training of work animals. Feeding, care and management of draft animals. Management of camel with special reference to rearing, feeding and watering. Behavioural studies of various draft animals. Economics of draft animals *vis-à-vis* machine power.

Sheep and goat: Selection of breeds and breeding systems for improving wool, mohair, meat and milk. Feeding practices for economic rearing. Scope of intensive milk and meat production from goat. Mutton and wool production from sheep. Low cost shelter management. Sheep and goat reproduction. Health management.

Poultry: Brooding of chicks. Management of growing, laying and breeding flocks. Shelter management. Biosecurity and environmental considerations. Cage layer management and well being of birds. Light management. Hatchery business management. Management during stress. Chick sexing. Maintenance of farm records. Health and sanitation problems. Prevention and disease control. Poultry shows. Handling care of table eggs and processing of birds for meat.

Equine: Care and management of horses, feeding and breeding systems, shelter management, shoeing, preparation and management of race horses.

Swine: Importance of pig as a meat animal. Selection of breeds and breeding systems for improving pig production. Feeding strategies for pigs. Care and Management of pregnant sows and unweaned pigtlets. Reproduction problems in pigs and remedial measures.

Rabbit: Economic importance. Important fur and meat type breeds. Housing, handling, feeding, watering, breeding, management, sanitation and health care of rabbits.

Unit 9: Wildlife Management
Status of wildlife in India and its conservation. Biological and ecological basis of management of wildlife. Breeding and feeding of wildlife in captivity. Health management.

Unit 10: Forage Production and Conservation
Classification of feeds and forages. Feed and fodder resources used for feeding of livestock and poultry. Nutritive value of feeds and fodders. Conservation and preservation of feeds and fodders. Annual and perennial fodder crops. Strategies for round the year fodder production. Pasture development and management. Enrichment of poor quality roughages.

Unit 11: Economics and Marketing of Livestock and Poultry and their Products
Economic principles as applied to livestock production. Production functions. Farm size, resources and product combinations. Cost concepts. Effect criteria in use of resources in livestock production. Maintenance of evaluation of different production records. Insurance and financing of livestock enterprises. Project formulation for setting up livestock farms. Different approaches to marketing of livestock and its products. Present status of cattle fairs and methods of selling livestock. Market news and information. Determination of prices of livestock products. Vertical integration in livestock products industries.

32. POULTRY SCIENCE

Unit 1: Poultry Genetics and Breeding

Phylogeny of poultry species, class, breed, variety and strains of chickens, ducks, geese, turkeys and other species of poultry. Mendelian traits in poultry. Inheritance of qualitative traits in poultry and their usefulness. Inheritance of comb, plumage and other qualitative traits. Sex-linked and sex influenced traits, their inheritance and usefulness. Economically important traits and their modes of inheritance. Gene action influencing the traits. Lethal and semi-lethal traits in poultry and their mode of inheritance. Quantitative traits. Inheritance of egg number, egg weight, growth rate, livability, fertility, hatchability, egg quality and other economic traits. Heritability and their estimates. Genetic correlations, their computation and application. Selection methods for genetic improvement-natural, artificial, directional, disruptive and stabilizing. Individual selection and family selection. Mass selection, combined selection and indirect selection. Construction of selection indices. Exploitation of additive and non-additive gene effects. Selection for specific characters. Recurrent and reciprocal recurrent selection. Part record versus complete record selection. Genotype and environment interaction. Relative merits and demerits of different methods of selection. Different mating systems-Diallel mating, pair mating, pen mating and block mating. Artifical insemination – collection and insemination techniques, dilution, diluents and cryopreservation of semen. Inbreeding and out-breeding. Pure-line breeding. Cross-breeding. Hybridization and hybrid vigour in improving economic traits, 3-way and 4-way crossing and development of hybrids. Modern trends in commercial poultry breeding. Major genes and their usefulness in poultry breeding in tropics. Dwarf gene and its usefulness in broiler breeding. Practical breeding programmes for developing broilers and layers. Selection for disease resistance. Immunogenetics. Blood group systems. Biochemical polymorphism and usefulness in poultry breeding. Development of transgenic chicken. Different molecular techniques for estimation of genetic diversity and similarity among breeds and lines of poultry. Scope of intergrating quantitative and molecular approaches for genetic selection in poultry.

Unit 2: Poultry Nutrition

Various nutrients and their role in poultry. Nutrient requirements of different species of poultry as per Bureau of Indian Standards and National Research Council of the USA. Partition of energy. Estimation of M.E. and T.M.E. Essential and critical amino acids and their inter-relationships. Evaluation of protein quality. Essential fatty acids. Essential vitamins and minerals and their functions. Nutrients deficiency, toxicity, synergism and antagonism. Naturally occurring toxiciants, their adverse effects on poultry and methods to overcome them. Fungal exotoxins of feed origin, their adverse effects on poultry, and methods to overcome them. Different systems of feeding wet mash, dry mash, crumble and pellet feeding. Restricted and phase feeding programme. Male separate feeding. Factors influencing the feed intake. Feed ingredients and sources of various nutrients. Quuality control and BIS specifications for feed ingredients. Unconventional feed stuffs and their utilization for economic feed formulation. Feed formulation for different species and groups. Least cost feed formulation and linear programming. Non – nutrient feed additives. Antibiotics, probiotics – direct feed microbials, antimicrobials, anticoccidials, performance-promoters, antioxidants, flavouring agents, colouring agents and other non-nutrient feed additives.

Unit 3: Avian Physiology

Homeostasis and its regulation; Characteristics features of endocrine glands; Regulation of feed and waer intake; Feed Passage rate in G.I. tract in relation to digestion and absorption efficiency; Functional regulation of digestion, absorption and metabolism of nutrients; Endocrine control and variable factors influencing growth process; Mechanisms that determines the sex and allows the development of left ovary and oviduct only; Physiological control of age at sexual maturity, ovarian follicular hierarchy, atresia, ovulation, oviposition, pause, clutch size and secretion of egg components; Photoperiodism and its role in optimization of reproductive functions; physiology of avain testes, spermatogenesis, semen ejaculation and its characteristics. Fate of sperm in oviduct and fertilization; Respiratory system – mechanisms of gaseous exchange; Thermoregulatory and stress mechanisms; Physio-biochemical stress responses and remedial approaches; Factors influencing reproductive functioning.

Unit 4: Poultry Products technology

Structure, chemical composition and nutritive value of egg. Various measusres of egg quality. Shell, albumen and yolk quality assessment. Factors influencing egg quality traits. Mechanism of deterioration of egg quality. Weight and quality grades of egg as per BIS, Agmark and USDA standards. Egg processing and storage. Different methods of preservation of table eggs and their relative merits and demerits. Preparation of various egg products and their uses. Processing, packing, preservation and grading of poultry meat. Further processing and fast food preparation. hysical, chemicals, microbial and organoleptic evaluation of meat quality. Processinng and utilization of egg and poultry processing waste.

Unit 5: Poultry Management

Poultry industry in India – past, present and future prospects. Statistics of egg and meat production in India. Major constraints facing the poultry industry. Selection, care and storage of hatching eggs. Principles and methods of incubation. Concept of modern hatcheries. Factors essential for incubation of eggs. Testing of eggs. High altitudes and hatchability of eggs. Embryonic communication. Photo acceleration and embryonic growth. Factors influencing hatchability and production of quality chicks. Analyzing hatchability problems. Hatchery hygiene. Fumigation procedure. Prevention of hatchery borne diseases. Utilization and disposal of hatchery waste. Prerequisite of good hatchery. Lay out of a modern hatchery. Equipments required in a modern hatchery. Single and multi-stage incubators. Hatchery business. Sexing, handling, packaging and transportation of chicks. Principles and methods of brooding. Space required for brooding, rearing, feeding and watering. Preparation of brooder house to receive young chicks. Forced feeding of turkey poults. Brooding of quails, ducklings and turkey poults. Managements during growing period. Overcrowding, culling. Management of replacement pullets for egg production and breeding stocks. Management of layers and breeders. Light management. Debeaking, dubbing and other farm routines. Littre management. Broodiness and forced moulting in layers. Management of turkey, ducks, quails and Guinea fowl. Summer and winter management.

Farm location and site selection. Ideal layout of poultry houses for different systems of rearing. Design of poultry houses like brooder, grower, broiler, layer and cage house, poultry processing unit, feed mill, etc. Environmentally controlled and open poultry houses. Types of construction

materials used. Cross-ventilation and ridge ventilation. Effect of pollution on production performance of birds. Ammonia control in poultry houses. Type of brooders, feeders, waters, laying nests, cages, etc. Automation in poultry production.

Unit 6: Economics and Marketing

Economic principles as applied to poultry production. Production functions. Farm size-resources and product combinations, efficiency criteria in use of resources in poultry production. Cost concept. Maintenance and evaluation of different production records. Insurance and financing of poultry enterprises. Project formulation for setting up of poultry farms and hatcheries. Production and requirement of poultry products in India and for exports. Various marketing channels. Transportation of eggs and chicken. Marketing approaches. Horizontal and vertical integration in poultry industry and their importance. Price spread in marketing of poultry and poultry products. Role of cooperatives in poultry farming.

Unit 7: Poultry Health Management

Common diseases of poultry – bacterial, viral, fungal, protozoan, parasitic and other emerging diseases of poultry, their prevention, control and treatment. Metabolic and nutrient deficiency diseases and disorders. Vaccination programmes. Deworming programmes. Control of coccidiosis, worms, ectoparasites and flies. Medication procedures. Cleaning and disinfection of poultry houses. Drinking water sanitation. General farm sanitation and hygiene. Safe disposal of dead birds and farm waste. Stress control. Heat stroke. Cold shock. Vices of poultry and their control. Bio-secutity measures in poultry farms.

33. AQUACULTURE

Unit 1: Hatchery and Grow Out Practices of Commercially Important Species
Aquaculture practices in different parts of the world, criteria for selection of organisms for aquaculture, site selection, design and construction of fish farms & hatcheries. Broodstock management and hatchery technology for different fish species; Extensive, semi-intensive and intensive aquaculture practices, running water aquaculture, recirculatory system, cage culture and pen culture; Packing and transportation methods.

Preparation and stocking of nursery and grow-out ponds; Water and soil quality management; Natural and supplementary feeds; Health management; Integration of aquaculture with agriculture and animal husbandry; Organic aquaculture; Aquaculture practices for freshwater fish (carps, catfish, snakeheads, mahseer, trouts), fresh water prawns (*M. rosenbergii*, *M. malcomsonii*), brackish water and marine fin fishes (sea bass, milkfish, mullets, rabbit fish, cobia, breams), shrimps (*Penaeus monodon, P. indicus* and *P. semisulcatus)*, mussels, oysters, pearl oysters, scallops, clams, sea cucumbers; Exotic fish introduction and its impact; Breeding and rearing of freshwater and marine ornamental fish; Packing and transport of live fish; International trade of ornamental fish.

Life history and cultivation of commercially important seaweeds; Emerging trends in sea farming; Good management practices (GMPs) for sustainable and responsible aquaculture; Sanitary and phytosanitary (SPS) measures.

Unit 2: Physiology and Nutrition of Fin and Shell Fishes
Nutritional requirements of cultivable fish and shell fish at larval, juvenile and adult stages; Role of amino acids, proteins, lipids, carbohydrates, nucleic acids, vitamins and minerals; Digestion, absorption & metabolism of nutrients, digestibility studies, protein evaluation, nutritional energetics; Feed formulations & pelletization, types of feed and their evaluation, feed additives (attractants, growth stimulants, probiotics), binders & nutraceuticals and their role in nutrition; Stability and storage properties of formulated feed; Methods of feeding; Nutritional pathology, toxins in feed, feed quality, brood stock and larval nutrition; Reproductive physiology, endocrine control of growth, moulting and reproduction; Stress physiology, physiological regulation of dietary intake, osmoregulation, acid-base regulation.

Unit 3: Genetics and Biotechnology
Principles of fish genetics; Inheritance of qualitative and quantitative traits in fish; Biochemical and molecular genetic markers; Selective breeding and hybridization; Chromosomes set manipulation and sex determination; Genetic engineering and production of transgenic fish; Fish genomics and proteomics; Use of molecular genetics markers in management of fish stock; Resources identifications, understanding breeding and stock structure, estimating the size of resources, identification of key habitats of the resources; Genetic conservations of fish stock; Cryopreservation of gametes; Inbreeding of stocks; Consequences and management of inbreeding; Molecular aspect of health management; Molecular diagnostics techniques and vaccines; GMOs; Exotic introduction and crossborder transportation of stock; Quality seed

production and certification, accreditation of the hatcheries; Quantitative trait loci and marker-assisted selection.

Unit 4: Fish Health Management

Common diseases in aquaculture - parasitic, bacterial, viral and fungal pathogens of fish and shellfish; Water, soil, environmental quality and effects on fish health; Pathological changes in diseases; Nutritional pathology; Epidemiology of diseases; Microbiological, histopathological and molecular techniques in disease diagnosis; Disease surveillance and reporting; Defense systems in fish - innate and acquired immunity; Antibody and cell-mediated immunity in fish and shellfish; Inflammation and response to diseases; Environment management; Methods for disease control : prophylaxis - vaccines, immunostimulants, probiotics; Chemotherapeutic agents, antibiotics and chemicals in health management; Fish quarantine systems - seed certification, germplasm exchange.

Unit 5: Aquatic Microbiology and Fish Food Organisms

Bacteria, virus, fungi, unicellular algae and protozoa in aquatic environment; Primary production, degradation, water pollution and purification; Physiology and biochemistry of aquatic microorganisms, their role in carbon, nitrogen, phosphorus, sulphur cycling and their impact on aquatic habitats and fish species; Role of microorganisms in fish production and fish health; Public health microbiology; Algal blooms and shellfish toxicities; Fish food organisms – bacterio, phyto-bacterio and zoo-planktons and their role in aquaculture systems; Mass culture of fish food organisms and their applications in hatcheries; Culture of microalgae, rotifers, artemia and other fish food organisms; Enrichment of live feed organisms.

Unit 6: Economics of Aquaculture Management Practices & Extension

Project formulation concepts; Preparation of bankable projects; Economics of different aquaculture practices; Farm management analysis; Domestic and export fish marketing – trends, channels, margins & regulations; Aquaculture extension system in India and other developing countries; Role of government and non government organizations in aquaculture development; Gender participation in aquaculture; Technology transfer programmes in aquaculture; Rural development programmes.

34. FISHERIES RESOURCES MANAGEMENT

Unit 1: Fisheries Resources

Major fisheries resources of the world, global trends in production; Target and non-target fisheries resources of the Indian subcontinent and the EEZ; Distribution, composition, trends and dynamics of major exploited fishery resources in hill streams, rivers, reservoirs, lakes, lagoons, estuaries, territorial waters, oceanic waters, deep sea oceanic islands; Straddling/shared stocks and non-conventional resources; Sports, game and ornamental fisheries; Major commercially exploited stocks, their potentials, status, bionomics, methods of capture and yields; Issues related to capture fisheries; Endangered and threatened species, *in-situ* and *ex-situ* conservation; Fisheries and Biodiversity Acts; Juvenile fishing, destructive gears, by-catch and discards; Status and impact of exotic species, accidental introductions; Guidelines and policies for exotics.

Unit 2: Fishery Biology

Life history of economically important fish species; Food and feeding habits, methods of studying food and feeding habits; Reproductive biology, maturity stages, fecundity, ova diameter studies and breeding cycles; Length- weight relationships; Condition Factor, Gonado-Somatic Index; Age and growth studies - methods for determination of age, study of growth rates, direct and indirect methods; Taxonomy of major fish groups; Recruitment, growth and mortality of fish in natural water bodies; Different analytical and Holistic models for fish stock assessment, their advantages and disadvantages; Catch per unit effort, Concept of Maximum Sustainable Yield and Maximum Economic Yield; Application of remote sensing and Geographical Information System (GIS) in resource mapping and forecasting; Mechanisms, methods and status of fish yield data acquisition, storage, retrieval and processing for national estimates; Ecosystem-based fisheries management tools; Monitoring, control and surveillance (MCS) systems for major fisheries; Computer softwares in stock assessment; Use of Virtual Population Analysis and Predictive models.

Unit 3: Aquatic Environment

Various aquatic habitats and fish faunal compositions, trophic relationships, distribution and abundance; Fisheries oceanography and marine fisheries; Limnological parameters; Influence of environmental parameters on fish abundance, distribution, resource resilience; Impact of fishing, aquaculture, other anthropogenic activities on the environment and fish stock. Disaster management in fisheries; Methods for increasing productivity of water bodies (Use of thermal energy and deep sea water through artificial upwelling, Use of ranching, Artificial reefs, FADs and their uses); Habitat degradation and its impact on fisheries; Pollution of water bodies and its impact; Bioindicators and Bioremediation; Protected areas (sanctuaries, marine parks, biosphere reserves and Ramsar sites); Potential fishing zones.

Unit 4: Fisheries Management

Concepts and principles of fisheries management; Fisheries Acts and Legislations, revisions and amendments; Fisheries policies, instruments and mechanisms for inland, coastal and open ocean fisheries management; Management of riverine, reservoir and lacustrine fisheries; Management of marine fisheries; Modes of fisheries management - Open access, regulated, advisory; participatory, user rights; International fishery regulations, treaties and instruments; Input control

measures such as access control, size, type, number and power of boats, duration of fishing; Output control measures such as Total Allowable Catch, Catch Quotas, Licensing, Technical control measures such as size limitations, closed fishing areas, closed seasons, size of nets and mesh size regulations, limited entry; Impediments to fisheries governance; UNCLOS, FAO Code of Conduct for Responsible Fisheries; India's commitment to international treaties and resolutions.

Unit 5: Fishing Technology

Different types of craft and gear, their operation and their maintenance; Selectivity of fishing gears, by-catch reduction devices in trawls, turtle excluder devices; Use of modern techniques and equipment for fish finding and capturing.

Unit 6: Economics and Marketing

Supply, demand and price dynamics in the fisheries sector; domestic and export marketing of fish and fish products, trends, channels, mechanisms, regulations, trade and non-trade barriers, concerns and strategies; modern marketing methods and channels, cold chains, storage; value addition; domestic and international market demands; International regulations and practices affecting Indian fisheries trade; WTO and Indian fisheries scenario; Issues in branding and labelling; Quality concerns; Growth of domestic and exports markets; Market trends and diversification; Emerging consumer preferences and trade practices; Fisheries co-operatives; Institutional support for fisheries development.

Unit 7: Fisheries Livelihood

Relevance of capture fisheries in food, nutrition, employment, income and livelihood securities of fishers; Vulnerability of fishers to changes in resource availability, exploitation and utilization patterns; Marginalization of fishermen, small scale processors and traders due to changing scenarios of product diversification, markets and trade; Impact of dams, river linking, CRZ, Biodiversity Bill, protected/closed area, fishing bans, closed seasons, protected areas, mangroves, sanctuaries and parks on the fisher communities. Land and water body use issues in fisheries. Role of extension in fisheries, mechanisms and modes of extension and their impact on capture fisheries and fisher's livelihood, alternative livelihood options; Management of conflicts within sub-sectors in fisheries; Women in fisheries, status, role, impact, future; Vulnerability of fishers to natural disasters and coping mechanisms in disaster management.

35. FISH PROCESSING TECHNOLOGY

Unit 1: Craft Technology

Fishing crafts of the world; Principles of design and construction; Corrosion protection; Craft materials - wood, marine plywood, fibreglass, reinforced plastic, aluminium, steel, ferro-cement; Bio-deterioration and preventive measures; FAO classification of fishing vessels; Different types of fishing vessels in India; General arrangements of fishing vessels; Basic principles of fishing vessel design; Stability of fishing vessels - factors affecting stability; Powering of fishing boats; Deck machinery for trawlers, seiners, gill netters and liner; Winches- net haulers, line haulers, power blocks, special purpose winches; Engine installation- types of engines for fishing vessels, four stroke cycle, two stroke cycle; Selection of engine for fishing vessels; Transmission systems - Reduction/reverse gear boxes; Modern navigation equipment, navigation and fishing lights; Life saving devices - life jacket, life buoy, life raft, SART, EPIRB.

Unit 2: Gear Technology

Gear Materials - Netting yarns, natural fibres and their classification, origin, properties & preservation; Synthetic fibres- Classification, manufacture, identification and comparative properties; Construction of netting twines; designation of netting yarns and twine twist-coeffeient; direction, yarn numbering system; Specification and characteristics of netting; Fishing accessories- Floats, buoys and sinkers, connectors and swivels, ground gear sheer devices, hooks; Classification of fishing gear. Fishing gears used in India; Fish behaviour in relation to fishing techniques; Factors affecting fishing gear design; Fishing gear selectivity - Selectivity of trawls, gill nets and lines; Model testing of fishing gear - flume tank; Structure and operation of trawls; Otter boards - principles of operation, variation in design; Structure, design variation and operation of purse seines, gillnets and trammel nets, lines and traps. Electrical fishing; Harvesting machines; Selective fishing gear and practices: By catch and discards, By catch reduction devices (BRDs), Turtle excluder devices (TEDs); Fish aggregating devices.

Unit 3: Process Biochemistry

Major and minor constituents of fish, their distribution and function- moisture, proteins, lipids, carbohydrates, vitamins and minerals; Glycogen in fish and its functions; Structure, classification and constitution of proteins; Use of functional properties of proteins for developing fish products; Essential amino acids and limiting amino acids and their requirements; Post-mortem changes -rigor mortis, autolysis, auto-oxidation and their significance; antioxidant mechanisms; Biochemical and microbial spoilage of fish; Lipids in fish -their structure and classification; Enzymes in fish -their classification and mechanism of action; Vitamins in fish - vitamin deficiency diseases; Minerals and trace elements in fish; Toxins and toxic substances in fish, their bioaccumulation and biomagnification; Biogenic amines.

Unit 4: Fish Processing Technology

Factors affecting spoilage of fish; Principles of fish preservation; Preservation of fish by curing (drying, salting and smoking); Water content, water activity (aw) and storage stability; Onboard handling of fish; sanitary and phyto-sanitary requirements for maintenance of quality; grading of fish; Chilling and freezing of fish - principles of chilling and freezing, crystallisation, nucleation, crystal growth, methods of chilling, transportation and marketing of chilled fish, the application

of freezing systems in fish processing; Changes in quality of chilled and frozen products during storage; Canning of fish and fish products- principles of canning, can materials, can shapes, process value calculation and spoilage of canned food; Modified atmosphere packaging (MAP) of fish and fish products; Accelerated freeze drying (AFD); Surimi and fish-mince products- the surimi process; Fish muscle proteins; Newtonian and non-Newtonian fluids; Irradiation- Radiation sources, units, dose levels, radarpertization, radicidation, radurization; Effects of irradiation on protein, fat and vitamin; Packaging and transportation of fish and fishery products - temperature modeling and relationships in fish transportation; transportation containers; Safety and quality and spoilage of fish during transportation; Fishery products and by-products exported from India; Packaging- aim, purpose and objectives, packaging and transportation of fresh fish, cured fish, canned fish, frozen fish, freeze-dried fish, by-products and value-added products; Additives- classes of additives, preservatives, antimicrobial additives.

Unit 5: Microbiology, Quality Management and Certification

Roles of bacteria and moulds in fish preservation; Modification of intrinsic and extrinsic parameters for fish preservation; Spoilage of fresh fish, chilled fish and processed fish products; Micro-organisms in frozen, canned and dried products, and their control; Human pathogenic bacteria, virus, molds and parasites in fish and fishery products; Sources of contamination and control measures; Fish quality evaluation and different indices of quality; Quality management in seafood processing- Concepts of Total quality management, HACCP, practical aspects of planning and implementing HACCP systems; Hazards in sea foods; Risk assessment; National and international standards - ISO 9000 series, ISO 22000. Codex alimentarius, ICMSF; Food Safety and Standards Act of India 2006; Role of BIS and EIA; Traceability issues in international trade.

Unit 6: Fishery Engineering

Selection of site for fish processing plant, layout and design- Canning plant, fish meal plant, surimi plant, freezing plant; Ideal requirements for construction of cold storage; Different types of cold storage; Seafood waste management; Refrigeration engineering- fundamental principles of refrigeration, refrigeration cycle; Refrigerants definition, type of refrigerant and their properties; types of condensers, type of boilers, type of evaporators; Machinery for handling and processing fish- Debonner, filleting machine, freshness analysers.

Unit 7: Economics and Marketing

Fisheries enterprise management; Trends of domestic and export marketing of fish and fishery products, modern marketing methods and channels – supply chain management, cold chain facilities and infrastructure; Value-addition; Institutional support for fish harvest and post-harvest practices.

36. FORESTRY

Unit 1

National Forest Policy 1894, 1952 and 1988; Indian Forest Act, 1927; Forest Conservation Act, 1980 and Wildlife Protection Act, 1972; Forests-extent, basis for classification and distribution in India; Geographical distribution and salient features of major world forest types; Phytogeographical regions and vegetation of India; Role of forests in national economy - productive, protective and ameliorative, tribal and rural livelihoods; Forest types of India: distribution and types; Succession, climax and retrogression; Concepts of biomass, productivity, energy flow and nutrient cycling in forest ecosystem; Migration and dispersal mechanism.

Unit 2

Concept and definition of agroforestry, social forestry, community forestry and farm forestry; Benefits and constraints of agroforestry; Historical development of agroforestry and overview of global agroforestry systems. Classification of agroforestry systems: structural, functional, socio-economic and ecological; Diagnosis and design of agroforestry system; Land capability classification and land use; Criteria of an ideal agroforestry design, productivity, sustainability and adoptability; Multipurpose tree species and their characteristics suitable for agroforestry.

Unit 3

Plant management practices in agroforestry; Tree-crop interactions: ecological and economic; Concept of complementarity, supplementarity and competition; Productivity, nutrient cycling and light, water and nutrient competition in agroforestry; Concept of allelopathy and its impact on agroforestry; Energy plantations - choice of species and management; Lopping of top-feed species such as frequency and intensity of lopping; Organic farming; Financial analysis and economic evaluation of agroforestry systems: cost benefit analysis and land equivalent ratio; Agroforestry practices and systems in different agro - ecological zones of India.

Unit 4

Extent and causes of land denudation; Effects of deforestation on soil erosion, land degradation, environment and rural economy; Wastelands: their extent, characteristics and reclamation; Watershed management and its role in social, economic and ecological development; Biomass production for fuel wood, small timber, raw material for plant-based cottage industries, non-wood forest products such as gums, resins & tannins, medicinal plants, essential oils, edible fruits, spices, bamboo and canes; Wood quality and wood preservation; Plywood and pulp industries.

Unit 5

Forest mensuration - definition, object and scope; Measurement of diameter, girth, height, stem form, bark thickness, crown width and crown length; Measurement methods and their principles. Measurement and computation of volume of logs and felled/standing trees; Construction and application of volume tables; Biomass measurement; Growth and increment; Measurement of crops; Forest inventory: kinds of enumeration, sampling methods, sample plots and photo interpretation; Geographic information systems and remote sensing - concept and scope.

Unit 6
Definition, object and scope of silviculture; Site factors - climatic, edaphic, physiographic, biotic and their influence on forest vegetation; Forest regeneration: natural and artificial; Silvicultural systems - high forest and coppice systems; Silviculture of important tree species - Populus, Eucalyptus, Dalbergia, Acacia, Tectona, Shorea, Prosopis, Casurina, Pinus, Gmelina, Azadirachta, Diospyros, Pterocarpus, Anogeissus, Santalum, Quercus and Albizia.

Unit 7
Seed collection, processing, storage, viability and pre-treatment; Seed dormancy and methods for breaking dormancy; Seed testing and germination tests; Seed certification and ISTA Rules; Forest nursery - need, selection and preparation of site, layout and design of nursery beds; Types of containers; Root trainers; Growing media and sowing methods; Management of nursery-shading, watering, manuring, fertilizer application, weed control, insect pest and diseases control; Planting techniques: site selection, evaluation and protection; Soil working techniques for various edaphic and climatic conditions; Planting patterns; Plant spacing, manure and fertilizer application, irrigation/moisture conservation techniques; Choice of species. Afforestation on difficult sites: saline-alkaline soils, coastal sands, lateritic soils, wetlands, ravines and sand dunes, dry and rocky areas, cold desert; Tending operations - weeding, cleaning, climber cutting, thinning - mechanical, ordinary, crown and selection thinning, improvement felling, pruning and girdling; Forest fires: causes, types, impacts and control measures; Major forest pests and weeds.

Unit 8
Forest management: definition and scope; Concept of sustained yield and normal forest; Rotation; Estimation of growing stock, density and site quality; Management of even aged and uneven aged forest; Regulation of yield in regular and irregular forests by area, volume, increment and number of trees; Working plan; Joint forest management; Conservation and management of natural resources including wildlife; Forest evaluation; Internal rate of return, present net worth and cost benefit analysis.

Unit 9
Tree improvement: nature and extent of variations in natural population; Natural selection; Concept of seed source/ provenance; Selection of superior trees; Seed production areas, exotic trees, land races; Collection, evaluation and maintenance of germplasm; Provenance testing. Genetic gains; Tree breeding: general principles, mode of pollination and floral structure; Basics of forest genetics - inheritance, Hardyweinburg Law, genetic drift; Aims and methods of tree breeding. Seed orchard: types, establishment, planning and management, progeny test and designs; Clonal forestry - merits and demerits; Techniques of vegetative propagation, tissue culture, mist chamber; Role of growth substances in vegetative propagation.

Unit 10

Forestry in bio-economic productivity of different agro-eco-systems and environmental management; Global overview and classification of agroforestry systems; Tree-crop interaction in agroforestry; Biomass production for fuel' wood, small timber, raw material for plants-based cottage industries, non wood forest products such as gums, resins, tannins, medicinal plants, essential oils, edible fruits, bamboos and canes; Principle and criteria of plant selection in agroforestry; Resource use-efficiency in agroforestry.

Unit 11

Measurement of trees and stand – diameter, girth, height, form and crown characteristics; Measurement methods and their principles; Volume/biomass estimation, volume tables; Measurement of rangeland productivity; Forest enumeration: sampling methods, sample plots, surveys and photo interpretation; Concept and application of GIS and remote sensing; Introduction to internal rate of return, present net worth, cost benefit analysis and land equivalent ratio; Agroforestry and environmental conservation; Role of green revolution in forest conservation in India.

Unit 12

Climate change: greenhouse effect, sources and sinks of green house gases, major greenhouses gases; Global climate change – its history and future predictions; Impact of climate change on agriculture, forestry, water resources, sea level; Livestock, fishery and coastal ecosystems; International conventions on climate change; Global warming: effect of enhanced CO_2 on productivity; Ozone layer depletion; Disaster management, floods, droughts, earthquakes; Tsunami, cyclones and landslides; Agroforestry and carbon sequestration.

Unit 13

Statistics: definition, object and scope; Frequency distribution; Mean, median, mode and standard deviation, introduction to correlation and regression; Experimental designs: basic principles, completely randomized, randomized block, Latin square and split plot designs.

37. ENVIRONMENTAL SCIENCE

Unit 1

Definition and scope of environment science and its interrelationship with other sciences and agriculture; Origin and evolution of the earth and its environs-atmosphere: hydrosphere, Lithosphere and biosphere; Biogeochemical cycles; Components of environment - biotic, abiotic and social; Weather and climate; History and evolution of human settlement; Effect of various developmental activities on environment.

Unit 2

Basic ecological concepts - habitat ecology, systems ecology, synecology, autecology; Ecosystem concept; Structure and functions of biotic and abiotic components; Energy in ecosystems and environment; Energy exchange and productivity-food chains and food webs-ecological pyramids, nutrient cycles and recycle pathways; Population - characteristics and measurement; Communities - habitats, niches, population dynamics, species and individual in the ecosystem; Recent trends in ecology; Types characteristic features, structure and function of forest, grassland, plantation, desert; Aquatic and agro-ecosystem; Ecological succession - types and causes.

Unit 3

Biodiversity concepts, levels and types, changes in tune and space, evolution, centres of origin of crops, species concept; Significance of biodiversity; Plant genetic resources, exploration and collection; Crop domestication, plant introductions; Migration and utilization; IUCN clauses and concept of threatened and endangered species; Biogeography; Principles of conservation of biological diversity *in-situ* and *ex-situ*. Causes of loss of biodiversity: introduction of exotics and invasive plants; Methods of conservation, role of national parks, wildlife sanctuaries, biosphere reserves; National and global conservation measures, institutions and conventions; Indian Biodiversity Act 2002; Biodiversity and economics with special reference to India; Biodiversity in relation to global environmental changes; Biodiversity hot spots in India and world; Biodiversity and life security.

Unit 4

Composition of air; Air pollution: sources and classification of major air pollutants; Smoke, smog, photochemical smog and SPM; Methods of air pollution monitoring; Effects of air pollutants on crops, vegetation, animals and human health; mitigation measures for combating air pollution; Factors affecting plant response to air pollution; Acid rain, physiological and biochemical effects of SO_2, HF, PAN and O_3 on vegetation, toxicity symptoms on vegetation, defence mechanism against air pollutants in plants, sensitive and tolerant plant species to air pollutants. National and international laws and policies on air pollution; Permissible limits of air pollutants in the residential, commercial and industrial areas; Noise pollution-concept and effects.

Unit 5

Soil and water pollution: sources and types of soil and water pollutants; Effects of pollutants on soil health and productivity; Radioactive pollutants, their life time and disposal; Point and non-point sources of water pollution, major types of water pollutants, their impacts on environment and agro-ecosystems; Pollution in fresh water bodies, ponds, lakes, rivers and wells. Effects of soil and water pollutants on crop plants, animals, microorganism and human health; National and International laws and maximum permissible limits of soil and water pollutants; Biomagnification and its impact on loss of biodiversity; Physical, chemical and biological properties of wastes; Effluent treatment processes for major industries *viz.* distilleries; paper and pulp, sugar, sewage and other agro-industrial wastes; Resource, product recovery, recycling and value addition to wastes; Biodegradation and bioconversion of organic wastes, composting, landfills; Vermicomposting, biogas. animal feed. mushroom cultivation etc.; Use of sludge, flyash, effluents and other agro industrial wastes in agriculture; Microbial, chemical and phytoremediation processes; Microbiological and public health aspects of waste disposal; Heavy metal contamination of environments, source and sinks of heavy metals.

Unit 6

Climate change: Global warming and greenhouse effect, sources and sinks of green house gases, major GHGs, atalytical techniques of monitoring greenhouse gases in atmosphere; Global climate change - its history and future predictions. Impact of climate change on agriculture, forestry, water resources, sea level rise, livestock, fisheries, coastal ecosystem and dynamics and pests and diseases and overall ecological processes; Climate change and food security; Contribution of agriculture and forestry to climate change; International conventions on climate change; Stratospheric ozone layer depletion-effect of UV radiation on plants and human health; Adaptation and mitigation strategies of climate change, global dimming agrobiological effects of CO_2 fertilization on crops; Carbon sequestration and clean development mechanism.

Unit 7

Energy consumption pattern in urban and rural India; Types of renewable sources of energy; Solar energy: concepts of heat and mass transfer; design of solar thermal system and their applications in heating. cooling. distillation. drying. dehydration etc., design of solar photovoltaic systems, power generation for rural electrification-water pumping, solar ponds; Wind energy for mechanical and electrical power generation, types of wind mills; Geothermal and tidal energy; Biogas from animal and agricultural wastes, types of biogas plants, utilization of biogas for heating, cooking lighting and power generation; Characteristics of biogas slurry and its utilization; Energy from biogas; Liquid fuels from petrocrops, energy plantation crops; Concepts of producer gas; characterization of materials for producer gas, types of gasifiers; Animals draft power and its utilization in rural sector; Briquetting of agro-wastes for fuel; Potential of renewable energy sources in India, Integrated rural energy programme; Causes of failure of biogas plants in rural India.

Unit 8

Natural resources of India: land, soil, water and forest and their conservation and management including wildlife; Effects of deforestation on soil erosion; Land degradation; Environment and rural economy; Wasteland: their extent, characteristics and reclamation; Soil and water conservation, rain water harvesting and watershed management; Desertification and biological invasion; Rain water harvesting; Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources; Disaster management: floods, droughts, earthquakes; Tsunami, cyclones and landslides; Nuclear hazards; Environmental impact assessment for physical, chemical, biological and socio-economic factors; Legislative implications of EIA, environmental impacts assessment and environmental auditing; Major global environmental issues; Human population and environment: population growth, variation among nations. Population explosion - Family welfare programme; World food resources; World food problems; Environment and human health; Environmental ethics: issues and possible solutions; Environmental policies and laws in India; Public environmental awareness; Human rights; Role of information technology in environmental and human health; Industrial pollutants; Sea weeds and their utilization in agar, alginic acid, carrageenan, agarose and agaropectin production; Impact of green revolution on the environments.

Unit 9

Frequency distribution, mean, median, mode and standard deviation; Normal, binomial and poisson distribution; Correlations - partial and multiple; Regression coefficients and multiple regression. Tests of significance F and Chi-square (X^2) tests; Experimental designs - basic principles, completely randomized, randomized block, Latin square and split plot designs.

38. AGRONOMY

Unit 1 : Crop Ecology and Geography

Principles of crop ecology; Ecosystem concept and determinants of productivity of ecosystem; Physiological limits of crop yield and variability in relation to ecological optima; Crop adaptation; Climate shift and its ecological implication; Greenhouse effect; Agro-ecological and agro climatic regions of lndia; Geographical distribution of cereals, legumes, oilseeds, vegetables, fodders and forages, commercial crops, condiments and spices, medicinal and aromatic plants; Adverse climatic factors and crop productivity; Photosynthesis, respiration, net assimilation, solar energy conversion efficiency and relative water content, light intensity, water and CO_2 in relation to photosynthetic rates and efficiency; Physiological stress in crops; Remote sensing: Spectral indices and their application in agriculture, crop water stress indices and crop stress detection.

Unit 2 : Weed Management

Scope and principles of weed management; Weeds' classification, biology, ecology and allelopathy; Crop weed competition, weed threshold; Herbicides classification, formulations, mode of action, selectivity and resistance; Persistence of herbicides in soils and plants; Application methods and equipment; Biological weed control, bio-herbicides: Integrated weed management; Special weeds, parasitic and aquatic weeds and their management in cropped and non cropped lands; weed control schedules in field crops, vegetables and plantation crops; Role of GM crops in weed management.

Unit 3 : Soil Fertility and Fertilizer Use

History of soil fertility and fertilizer use; Concept of essentiality of plant nutrients, their critical concentrations in plants, nutrient interactions, diagnostic techniques with special emphasis on emerging deficiencies of secondary and micro-nutrients; Soil fertility and productivity and their indicators; Fertilizer materials including liquid fertilizers, their composition, mineralization, availability and reaction products in soils; Water solubility of phosphate fertilizers; Slow release fertilizers, nitrification inhibitors and their use for crop production; Principles and methods of fertilizer application; Integrated nutrient management and bio-fertilizers; Agronomic and physiological efficiency and recovery of applied plant nutrients; Criteria for determining fertilizer schedules for cropping systems direct, residual and cumulative effects; Fertilizer related environmental problems including ground water pollution; Site-specific nutrient management; Contamination of heavy metals in peri-urban soils and their remediation.

Unit 4 : Dryland Agronomy

Concept of dryland farming; dryland farming vs rainfed farming; History, development, significance and constraints of dryland agriculture in India; Climatic classification and delineation of dryland tracts; Characterization of agro-climatic environments of drylands; Rainfall analysis and length of growing season; Types of drought, drought syndrome, effect on plant growth, drought resistance, drought avoidance, drought management; Crop Planning including contingency, crop diversification, varieties, cropping systems, conservation cropping and mid-season corrections for aberrant weather conditions; Techniques of moisture conservation in-situ to reduce evapotranspiration, runoff and to increase infiltration; Rain water harvesting and recycling concept, techniques and practices; Timelines and precision key factors

for timely sowing, precision in seeding, weed control; Fertilizer placement, top dressing and foliar application, aqua-fertigation; Concept and importance of watershed management in dryland areas.

Unit 5 : Crop Production in Problem Soils

Problem soils and their distribution in India, acid, saline, waterlogged and mined - soils; Response of crop to acidity, salinity, sodicity, excess water and nutrient imbalances; Reclamation of problem soils, role of amendments and drainage; Crop production techniques in problem soils - crops, varieties, cropping system and agronomic practices; Effects of water table fluctuation on crop growth; Degraded lands and their rehabilitation.

Unit 6 : Crop Production

Crop production techniques for cereals, millets, legumes, oilseeds, fiber crops, sugarcane, tobacco, fodder and pasture crops including origin, history, distribution, adaptation, climate, soil, season, modern varieties, fertilizer requirements, intercultural operations, water requirement. weed control, quality components, industrial use, economics and post harvest technology.

Unit 7 : Agricultural Statistics

Frequency distribution, standard error and deviation, correlation and regression analyses, co-efficient of variation; Tests of significance-t, F and chi-square (X^2); Data transformation and missing plot techniques; Design of experiments and their basic principles, completely randomized, randomized block, split plot, strip-plot, factorial and simple confounding designs; Efficiency of designs; Methods of statistical analysis for cropping systems including intercropping; Pooled analysis.

Unit 8 : Sustainable Land Use Systems

Concept of sustainability; Sustainability parameters and indicators; Conservation agriculture; Alternate land use systems; Types, extent and causes of wasteland; Shifting cultivation; Agro forestry systems; Agricultural and agro-industrial residues and its recycling, safe disposal; Allelopathy and biomass production.

Unit 9 : Basics of Soil and Water

Soil and water as vital resources for agricultural production; Occurrence of groundwater, groundwater aquifers, exploration of groundwater; Hydrological cycle; Soil-plant water relationship; Fate of rain water received at the soil surface, runoff and infiltration reciprocity, factors affecting infiltration, means to enhance infilterability of soil, mechanical and biological means to reduce runoff and soil loss; Water harvesting for crop life saving irrigations; watershed management; Soil and water conservation; Contingent crop plans and other strategies for aberrant weather conditions; Cropping patterns, alternate land use and crop diversification in rainfed areas; Analysis of hydrologic data and their use.

Unit 10 : Soil Water Relationship

Soil water relations, water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water; Soil irrigability, classifications, factors affecting profile water storage; Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head;

Movement of soil water saturated and unsaturated water flow; Field water budget, water gains and water losses from soil, deep percolation beyond root zone, capillary rise; Evapotranspiration (ET), scope for economizing water, measures for reducing direct evaporation from soil and crop canopies; Soil physical properties in relation to plant growth and development; Erodability of soils and their prevention.

Unit 11 : Plant Water Relationship

Plant water relations: Concept of plant water potential, cell water relations, plant water potential and its components; Significance of osmotic adjustment, leaf diffusive resistance, canopy temperature, canopy temperature depression (CTD); Water movement through soil - plant atmosphere systems, uptake and transport of water by roots; Development of crop water deficit, crop adaptation to water deficit, morpho physiological effect of water deficit; Drought tolerance, mechanisms of drought tolerance, potential drought tolerance traits and their measurements. management and breeding strategies to improve crop productivity under different patterns of drought situations of limited water supplies; Effect of excess water on plant growth and production; Types of droughts, drought indices.

Unit 12 : Irrigation Water Management

Management of irrigation water; History of irrigation in India; Major irrigation projects in India; Water resources development; Crop water requirements; Concepts of irrigation scheduling, Different approaches of irrigation scheduling; Soil water depletion plant indices and climatic parameters; Concept of critical stages of crop growth in relation to water supplies; Crop modeling, crop coefficients, water production functions; Methods of irrigation *viz.* surface methods, overhead methods, drip irrigation and air conditioning irrigation, merits and demerits of various methods, design and evaluation of irrigation methods; Measurement of irrigation water, application and distribution efficiencies; Management of water resources (rain, canal and ground water) for agricultural production; Agronomic considerations in tile-design and operation of irrigation projects, characteristics of irrigation and family systems affecting irrigation management; lrrigation legislation; Water quality, conjunctive use of water, irrigation strategies under different situation of water availability, optimum crop plans and cropping patterns in canal command areas; Socio-economic aspects of on-farm water management; Irrigation water distribution, Irrigation efficiencies; Design of irrigation canals, design of irrigation structures; Interaction between irrigation and fertilizers.

Unit 13 : Management of Problematic Soils and Water

Problem soils and their distribution in India; Salt-affected, acidic, water logged soils; Ground water resources, water quality criteria and use of brackish waters in agriculture; Excess salt and salt tolerant crops; Hydrological imbalances and their corrective measures; Concept of critical water table depths for crop growth; Contribution of shallow water table to crop water requirements; Management strategies for flood prone areas crop and crop calendar for flood affected areas; Drainage for improving water logged soils for crop production; Crop production and alternate use of problematic soils and poor quality water for agricultural and fish production; Amelioration of salt affected soils.

39. AGRICULTURAL METEOROLOGY

Unit 1 : General Meteorology

Laws of radiation: Planck's law, Stephan-Boatman law, Wein's displacement law; Kirchoff's law, Beer's law and Lambert's, Cosine law, Solar constant, length of day; Atmospheric and astronomical factors affecting depiction of solar radiation; Ozone hole; Direct and diffuse radiation; Heat transfer, convection, conduction and radiation; Concepts of latent and sensible heat; Radiant flux and flux density; Atmospheric motion balanced forces; Gas laws, pressure gradient, isobars, hydraulic equation and its application; Carioles force, geotropic, gradient and cyclostrophic winds; Pressure systems; Cyclones and anticyclonic motions: trough, ridge and col; Thermal wind; Contour charts, Concepts of specific heat at constant volume and pressure; First and second laws of thermodynamics, vapor pressure, specific humidity, relative humidity, mixing ratio, absolute humidity and dew point temperature; Vapour pressure deficit; Psychometric equation, entropy, T-phi gram; Vertical stability of atmosphere, virtual temperature and potential temperature; Moist and dry adiabatic processes; Clouds their description and classification; Condensation process-artificial rain making; Bergeron-Findeison theory; Dew, frost, fog, mist, haze thunderstorm and hail; Air masses and fronts; Extra tropical cyclones; Land and sea breeze; Mountain and valley winds; Tropical cyclones and their structures; Weather variables and their measurements; Units for measurements of momentum, force work, power, surface tension, pressure, temperature; Thermal - conductivity and diffusivity, resistance, radiation light intensity and water vapour.

Unit 2 : General Climatology

Elements of weather and climate; Seasonal distribution of radiation, rainfall. temperature sunshine, wind pressure over India; Climatic classification - Koppen and Thornthwaite; Climatology principles of weather phenomena occurring in four main seasons of India; Mechanism of Indian monsoons; Climatic variability, recent trends, factor affecting rainfall distribution, cyclones and cyclonic tracks over the Indian region; North western disturbances and monsoon breaks; Drought climatology, rainfall and its variability, atmospheric and agricultural droughts intensity, duration, beginning and end of drought and wet spells; Moisture availability indices; Heat and cold waves; Contingents, maritime and monsoon climates, El-Niño, La Nino and their impact on Indian rainfall systems.

Unit 3 : Agricultural Climatology

Meaning and scope; Effect of thermal environment on growth and yield of crops; Cardinal temperatures; Thermoperiodism, photoperiodism; Vont Hoff's law, phenology of crops; Heat unit concept, thermal time and thermal use-efficiency and their applications; Length of growing period determination. contingency planning far different weather aberrations; Meteorological factors associated with incidence and development of crop pests and disease, potato blight, apple scan, groundnut red hairy caterpillar, locust etc.; Effect of climate on humans and animals, warm and cold season indices for comfort zones, role of weather in animal disease and protection against weather hazards.

Unit 4 : Micrometeorology

Concept of micro, meso and macro meteorology; Micrometeorological processes near bare ground and crop surfaces; Shearing stress, molecular and eddy diffusion, forced and tree convection; Boundary layer, frictional velocity, roughness length and zero plane displacement; Micrometeorology of crops, rice and wheat; Day and night radiation, humidity, temperature, wind and CO_2 profiles in crop canopies; Richardson number, Reynolds analogy, exchange coefficients, fluxes of momentum, water vapors, CO_2 and heat; Inversion and its effect on smoke plume distribution; Windbreaks and shelterbelts, different methods on modification of field microclimate; Frost protection, spectral properties of vegetation; Light interception by crop canopies as influenced by leaf area index, leaf arrangement and leaf transmissibility, extinction coefficient and radiation use–efficiency; Microclimate of field crops, forest and orchards etc.

Unit 5 : Evapotranspiration

Hydrological cycle and concept of water balance, concepts of evaporation. evapotranspiration, potential and actual evapotranspiration, consumptive use, different approaches of ET determination empirical methods, energy balance and Bowen's ratio methods, water balance single and multilayered soil methods, aerodynamic, eddy correlation and combination approaches, field lysimetric approaches and canopy temperature based methods; Advantages and limitations of different methods; Water use and water use-efficiency, dry matter production and crop yield functions; Irrigation scheduling based on ET; Advective energy determination and its effect on water use by crops; Physiological variation in relation to crop growth and development.

Unit 6 : Crop Weather Modeling

Concepts of mechanistic and deterministic models; General features of dynamical and statistical modeling techniques; Crop weather models and their use in crop yield assessments; Crop weather analysis models, empirical, statistical models, and crop growth simulation models for yield assessment; Use of SPA and CERES models, concepts for crop growth and yield; Advantages and limitations of modeling, climatic change, greenhouse effect, CO_2 increase, global warming and their impact on agriculture.

Unit 7 : Weather Forecasting for Agriculture

Crop weather calendars: Short, medium and long range weather forecasting; Monsoon onset and rainfall forecasts; Weather forecasting and agro-advisories; Use of satellite cloud imageries in weather forecasting; Synoptic charts and synoptic approach to weather forecasting, use of medium, long range and vegetative indices based agro meteorology forecasts for monitoring crop prospects and crop yield forecasts; Meteorological satellites for weather forecasts; Forecast of Indian monsoon rainfall; Early warning systems for agriculture operation forecasts.

40. AGRICULTURAL PHYSICS

Unit 1

Definition and scope of Agricultural Physics, major components of Agricultural Physics (Soil Physics, Biophysics, Agricultural Meteorology, Remote Sensing, Geographic Information System and Simulation); Electromagnetic radiation and its interaction with matter; Optical and microwave remote sensing; Spectral characteristics of soil and vegetation, spectroradiometer, infrared thermometer, spectral vegetation indices and their applications; Hyperspectral remote sensing, use of remote sensing for resource management, crop water use, crop growth monitoring, land cover mapping and land use planning, drought monitoring and soil moisture availability; Principal of geographic information system and global positioning system; Geoinformatics - components and applications; Radioactivity, radio-tracers for use in agricultural research, X-ray diffraction; Electron and polarizing microscopes; AAS; UV, visible and IR spectrophotometer; Nuclear magnetic resonance; Nano-technology.

Unit 2

Planck's law of radiation, Stefan-Boltzman's law, Wien's displacement law, Kirchoff's law, Beer's law, and Lambert's law; Solar constant, day length, direct and diffuse solar radiation, ozone hole; Convection and conduction; Gas laws, Carioles force, geosgrotopic and cyclostropic winds, pressure systems, cyclonic and anti-cyclonic motion, thermal wind, contour chart, relative and specific humidity, humidity mixing ratio, vapour pressure deficit, dew point, psychrometric equation; Vertical stability of atmosphere, virtual and potential temperatures, moist and dry adiabatic processes, clouds classification, artificial rain making, Bergeron-Findeison theory, dew, frost, fog, mist, haze, thunderstorm and hail, air masses and fronts, extra-tropical cyclones, land and sea breeze, mountains and valley winds, tropical cyclones.

Unit 3

Major soil groups of India - their characteristics and distribution; Soil profile, diagnostic horizons; Physical and chemical composition of soil; Soil colloids; Role of soil organic matter in maintaining soil fertility; Soil texture analysis, Stokes' law; Soil as a three phase disperse system; Mass-volume relationships, bulk density, porosity and pore size distribution; Soil structure - classification and structural indices and evaluation in relation to crop growth; Soil crust and seedling emergence; Management of highly permeable, slowly permeable, desurfaced and compacted soils; Soil consistency, hydration, swelling, shrinkage, hardening and cracking; Soil tilth and tillage, zero, minimum and conventional tillage; Resource conserving technologies; Dynamics of soil physical environment under different cropping systems.

Unit 4

State of soil water, Gibb's free energy and thermodynamics concept of soil water potential; Soil moisture characteristics and hysteresis; Darcy's law, theory of saturated and unsaturated flow; Soil water content measurement techniques - neutron scattering, gamma attenuation, time-domain refectometry, pressure plate and membrane apparatus, tensiometer, gypsum block and thermocouple psychrometer; Soil hydraulic conductivity and diffusivity, infiltration rate and soil infiltrability; Estimation of evapotranspiration, lysimeters; Solute transport in soil and nutrient availability to crops; Irrigation water management under variable water supply; Quality of irrigation water; Effect of saline, sodic and industrial effluents on soil properties and crop

growth; Water use-yield relationships, water production functions, simulation of soil water balance.

Unit 5

Soil air composition; Movement of soil air, Fick's law of diffusion, Oxygen diffusion rate, plant growth in relation to soil aeration; Sources of soil heat, components of soil heat balance; Thermal properties of soil and heat capacity, thermal conductivity and diffusivity; Factors affecting soil temperature; Soil temperature measurement - thermocouples, thermistors, heat flux plate; Effect of soil temperature on plant growth including germination, root and shoot growth; Effect of soil temperature on microbial activities in nutrient transformation; Management of soil thermal environment.

Unit 6

Principles of soil and water conservation; Hydrologic cycle, rainfall-runoff relationships, sediment yield, different types of soil erosion and extent of problem in India; Soil erodibility, universal soil loss equation; Water erosion, control of water erosion including gullies and ravines; Wind erosion - factors and control options, sand dunes formation and stabilization, shelter belts and windbreaks; Dryland farming, use of mulches, tillage and afforestation for soil and water conservation; Rainwater harvesting and recycling; Characterization and evaluation of soil and land quality; Land capability classification; Causes of land degradation and management for prevention/restoration; Identification, monitoring and management of waste lands; Concept of watershed - its characterization and management.

Unit 7

Interactions in biological systems, structure and functions in living organisms, biomolecules; Life forms - unicellular and multicellular; Structure of plant and animal cells, membranes and their modifications; Bioelectricity of cell membrane and measurement; Protein structure - amino acids, lipids; Bioenergetics; Laws of thermodynamics; Transport phenomena in biological systems.

Unit 8

Weather and climate, weather phenomenon in Indian agriculture, metereology and crop growth and topics of Agrometeorology

Unit 9

Crop-weather interaction models and their use in crop yield assessment; Global climate change and its impact on agriculture; Adaptation and mitigation strategies to sustain agricultural production under climate change; Crop weather calendars; Short, medium and long range weather forecasting; Agroadvisories; Meteorological satellites for weather forecast; Early warning systems for agricultural operations forecast.

Unit 10

Measures of central tendency and dispersion; Binomial distribution, chi-square (X^2) test, correlation and regression, t and F tests; Experimental designs - randomized, Latin square, split-plot and factorial; Spatial statistic variogram and kriging techniques; Principles of computer software; Methods of information storage, retrieval and transfer; Crop simulation model, Markov-chain probability and its application; Normal, binomial and gamma distribution.

41. SOIL SCIENCE - PEDOLOGY

Unit 1: Soil Genesis
Pedology in relation to other disciplines; Rocks, minerals and other soil forming materials; Geomorphic processes in land evolution; Geomorphology in soil mapping; Soil-landscape relationships; Concepts of soil genesis; Weathering of rocks and minerals; Factors of soil formation; Pedogenic processes and their relationships with soil properties; Soil development; Pedon, polypedon, soil profile, horizons and their nomenclature.

Unit 2: Soil Mineralogy
Structure, characteristics and identification of soil minerals; Genesis and transformation of clay minerals; Clay-organic complexes; Non-crystalline components of soils; Mineralogy of major soil groups of India.

Unit 3: Soil Survey, Mapping and Cartography
Soil survey techniques; Types of soil surveys, base maps and mapping units; Remote-sensing techniques for soil resource inventorization; Cartography – techniques for preparation of base maps, soil and other interpretive maps, processing of field sheet, compilation and abstraction of maps in different scales; Geographic Information System - concepts, components and application in natural resource mapping.

Unit 4: Soil Classification
Concepts, history and utility of soil classification; FAO/UNESCO world soil reference system; USDA Soil Taxonomy - epipedons, diagnostic subsurface horizons and other diagnostic characteristics, soil moisture and temperature regimes, categories of the system and their criteria; Orders, sub-orders, great groups and other categories of Taxonomy classification; Soil micromorphology – importance, thin section studies for identification of diagnostic horizons and other pedological features, and their interpretation for soil genesis and classification; Soil groups of India - distribution, problems, potentials and placement in Soil Taxonomy.

Unit 5: Soil Correlation and Land Use Planning
Soil correlation - concepts and correlation at various levels; Interpretation of soil resource information for agricultural and non-agricultural uses; Land capability and land irrigability classification; Land evaluation and land use planning; Soil degradation; Concept of benchmark soils for agrotechnology transfer; Agro-ecological regions of India.

Unit 6: Soil Physics and Conservation
Soil texture and soil structure indices and evaluation; Mass-volume relationships in soil; Soil moisture retention characteristics, energetics of soil water in relation to its availability to plants, water movement in soil, soil water balance; Soil temperature, heat content and heat flow in soil; Soil air and aeration status; Universal soil loss equation; Principles of soil and water conservation; Different types of soil erosion and its control; Integrated watershed management.

Unit 7: Soil Chemistry
Chemical composition of soil; Soil reaction; Soil colloids; Ion exchange, adsorption and desorption, ion activity and ionic equlibria in soils; Quantity-intensity relationships of nutrients; Fixation and release of nutrients; Development, characteristics and management of acidic, saline, sodic and waterlogged soils.

Unit 8: Soil Fertility, Fertilizers and Manures
Essential elements in plant nutrition; Soil fertility evaluation - soil, plant tissue and biological tests; Soil organic matter decomposition, humus formation and role in soil fertility; Soil organisms, biological N-fixation and nutrient transformations; Mycorrhiza and plant nutrition; Manures, fertilizers, biofertilizers and their use; Integrated nutrient management; Quality control of fertilizers; Fertility status of major soil groups of India.

Unit 9: Methods of Soil Analysis
Methods of soil analysis - particle size distribution, bulk and particle density, moisture constants, soil reaction, organic carbon, alkaline earth carbonates, cation exchange capacity, exchangeable cations, available nutrients; Instrumental methods - flame photometry, absorption spectrophotometry, potentiometry, conductimetry, X-ray diffractometry, thermal analysis and polarising microscopy.

Unit 10: Statistics
Measures of central tendency and dispersion; Correlation and regression; Tests of significance - t and F tests; Principles of computer use.

42. SOIL SCIENCE – SOIL CHEMISTRY/ FERTILITY/MICROBIOLOGY

Unit 1
Soil as a natural body; Rocks and minerals - their classification, composition and characteristics; Weathering of rocks and transformation of minerals; Soil formation, soil survey and classification as per Soil Taxonomy; Major soil groups of India - their characteristics and distribution; Land-use classification.

Unit 2
Soil physical properties - their influence on plant growth; Soil moisture retention characteristics; Energetics of soil water in relation to its availability to plants; Water and solute movement in soil; Soil temperature; Soil aeration; Soil strength and soil crusting.

Unit 3
Chemical composition of soil; Soil colloids - structure, composition, constitution of clay minerals, amorphous clays and other non-crystalline silicate minerals, oxide and hydroxide minerals; Charge development on clays and organic matter; pH-charge relations; Buffer capacity of soils.

Unit 4
Ion exchange and sorption phenomena; Adsorption isotherms; Cation exchange equations and ratio law; Ionic activity in soil and its measurement; Donnan distribution of ions and its thermodynamic treatment; Double layer theory; Boltzman distribution; Electro-kinetic phenomena - electro-osmosis, electrophoresis, zeta potential and streaming potential; Chemical equilibria in soils, acid base equilibria, oxidation-reduction equilibria, etc; Chemistry of waterlogged soils, redox potential and nutrient availability; Solubility equilibria for carbonates, alumino-silicates, phosphates and iron.

Unit 5
Soil organisms - their role in organic matter decomposition and nutrient transformations; Soil organic matter - its nature, constitution and role in soil formation, soil fertility and plant growth; Biochemistry of humus formation; Soil enzymes; Biology of root-soil interface; Soil organisms and pedogenesis; Biological equilibrium in soil; Biological nitrogen fixation; Biofertilizers; Mycorrhiza and plant nutrition.

Unit 6
Essential elements in plant nutrition; Nutrient cycles in soil; Transformation and transport of nutrients (N, P, K, S, Fe and Zn) in soil; Manures and fertilizers; Chemistry of production of different fertilizers; Fertilizers mixtures; Slow release fertilizers and nitrification retarders; Quality control of fertilizers; Mechanisms of ion absorption by plants.

Unit 7

Modern methods of soil, plant and fertilizer analysis; Flame photometry and inductively coupled plasma optical emission spectroscopy; Spectrophotometry - visible, ultra-violet and infrared; Atomic absorption spectrophotometry; Potentiometry and conductimetry; X-ray diffractometry; Mass spectrometry; Experimental designs for pot culture and field experiments; Statistical measures of central tendency and dispersion; Correlation and regression; Tests of significance - t and F tests; Computer use in soil research.

Unit 8

Soil fertility evaluation - soil testing, plant and tissue tests and biological methods; Common soil test methods for fertilizer recommendation; Soil test-crop response correlations; Mechanisms of nutrient losses from soil and control measures; Direct, residual and cumulative effects of fertilizers; Integrated nutrient management; Organic farming; Sustaining soil fertility; Use of isotopic tracers in soil research.

Unit 9

Nature, properties and development of acid, acid sulphate, saline and sodic soils and their management; Lime and gypsum requirements of soils; Irrigation water quality - EC, SAR, RSC and specifications; Principles of soil and water conservation; Types of soil erosion, factors affecting soil erosion, and control measures; Use of remote sensing in soil and water conservation.

Unit 10

Interaction of soils and pesticides; Bio-remediation of pesticide-contaminated soils; Heavy metal toxicity and soil pollution; Soil pollution through industrial effluents, sewage, pesticides and fertilizers; Soil factors in emission of greenhouse gases; Carbon sequestration in mitigating greenhouse effect; Types, factors and processes of land degradation and remediation; Geographic Information System in monitoring, diagnosis and mapping of land degradation; Radio-active contamination of soil.

43. SOIL SCIENCE – SOIL PHYSICS / SOIL AND WATER CONSERVATION

Unit 1

Soil as a natural body; Rocks and minerals in relation to soil development; Weathering and soil formation; Soil profile, diagnostic horizons; Soil classification; Major soil groups of India their characteristics and distribution; Creation of soil data-base and its various applications.

Unit 2

Physical and chemical composition of soil; Soil colloids; Clay-organic matter and clay-humus complexes; Clay minerals - genesis, structure, characteristics and identification; Soil reaction; Essential elements in plant nutrition; Mechanisms of ion absorption by plants; Fixation, transformation and release of nutrient ions in soil; Nutrient movement in soil - mass flow, diffusion and interception processes; Fertilizers and manures in relation to plant nutrition; Role of soil organic matter in maintaining soil fertility; Soil organisms - their role in organic matter decomposition and nutrient transformation; Biological nitrogen fixation; Denitrification; Biofertilizers and their use.

Unit 3

Soil as a three phase disperse system; Mass volume relationships; Methods of soil physical analysis - bulk density porosity, pore-size distribution; Soil water content measurement by neutron scattering, gamma attenuation and time domain reflectometry; microwave remote sensing technique; Soil water potential measurement - pressure plate and membrance apparatus, tensiometers, gypsum block, thermocouple psychrometer; Saturated and unsaturated hydraulic conductivity; Soil water diffusivity; Soil aggregate analysis - wet and dry sieving devices; Oxygen diffusion rate; Soil temperature measurement - thermocouples, thermisters, heat flux plate; Isotopes and radiations in soil physical investigations.

Unit 4

Soil texture mechanical analysis; Stokes' law; Soil texture in relation to plant growth; Soil structure classification, genesis and theory of aggregate formation, indices and evaluation; Soil crust and seedling emergence; Management of highly permeable, slowly permeable, desurfaced and compacted soils; Soils structure and plant growth; Dynamic properties of soils - consistency, hydration, swelling, shrinkage, hardening and cracking; Soil tilth and tillage, soil tilth evaluation; Soil physical properties under different cropping systems; Root growth in relation to soil physical properties.

Unit 5

State of soil water; Soil water potential - Gibbs free energy and thermodynamic concept of soil-water potential; Soil moisture characteristics and hysteresis; Water flow - Darcy's law, theories of saturated and unsaturated flow, hydraulic conductivity and diffusivity, and factors affecting it; Infiltration, redistribution and evaporation of soil water; Soil water balance and measurement of its components; Estimation of evapotranspiration; Solute transport in soil; Soil-plant-water atmosphere relationships, energy balance in soil-plant-atmosphere-continuum; Soil water availability in relation to plant growth; Irrigation water management under adequate and limited water supply; Irrigation scheduling; Water-use efficiency; Water use-yield relationships; Quality of irrigation water; Effect of saline, sodic and industrial effluents on soil properties and crop growth.

Unit 6

Soil air composition, characterisation of soil aeration satus; Movement of soil air - mass flow and Fick's law of diffusion; Soil aeration in relation to plant growth; Sources of soil heat and heat balance, thermal properties of soil and heat capacity, thermal conductivity and diffusivity; Heat flow in soil; Factors affecting soil temperature environmental factors; Effect of soil temperature on plant growth including germination, root and shoot growth; Effect of soil temperature on microbial activity and nutrient transformation; Management of soil thermal environment.

Unit 7

Principles of soil and water conservation; Hydrologic cycle; Rainfall runoff relationships, estimation of runoff and sedimentation yield; Different types of soil erosion, nature and extent of the problem in India; Water erosion, and factors affecting it; Soil physical properties in relation to water erosion and soil erodibility; Universal soil loss equation and evaluation of its parameters; Control of water erosion including gullies and ravines; Wind erosion equation and evaluation of parameters, factors affecting, processes and control; Sand-dune formation and stabilization; Shelter belts and wind breaks; Soil conservation survey; Soil moisture conservation and dryland farming; Use of mulches, grasses, tillage and afforestation for soil and water conservation; Rain water harvesting and recycling.

Unit 8

Characteristics of electromagnetic radiation and its interaction with matter; Principles of optical and microwave remote sensing; Spectral characteristics of soil and vegetation and factors affecting these; Spectral vegetation indices and their applications; Principles of geographic information system and global positioning system.

Unit 9

Soil and water as nutural resources; Characterization and evaluation of soil and land quality indicators; Land capability classification; Productivity rating; Causes of land degradation; Management of soil physical properties for prevention/restoration of land degradation; Identification, monitoring and management of waste lands; Land use-land cover mapping and land use planning using conventional and remote sensing techniques; Concept of watershed - its characterization and management.

Unit 10

Measures of central tendency and dispersion; Bionomial distribution; Chi-square (X_2) test; Correlation and regression; t and F tests; Experimental designs – randomized, Latin square, split-plot and factorial designs; Spatial statistic variogram and kriging techniques; Principles of computer use; Windows-based use of computer software and modern methods of information storage, retrieval and transfer.

44. AGRICULTURAL CHEMISTRY

Unit 1

General chemistry: Structure and bonding: Atomic orbitals, electronic configuration of atom (L-S coupling) and the periodic properties of elements; ionic radii, ionisation potential, electron affinity, electronegativity, concept of hybridization; Molecular orbitals and electronic configuration of homonuclear and heteronuclear diatomic molecules; Shapes of polyatomic molecules; VSEPR theory; Symmetry elements and point groups for simple molecules; Bond lengths, bond angles, bond order and bond energies; Types of chemical bonds (weak and strong) intermolecular forces, structure of simple ionic and covalent solids, lattice energy.

Unit 2

Acids and bases - Bronsted and Lewis acids and bases, pH and pKa, acid-base concept in non-aqueous media; HSAB concept; Buffer solution; Acid-base indicators; Redox reactions, oxidation numbers. redox potential. redox indicators.

Unit 3

Energetics and dynamics of chemical reactions entropy, free-energy, relationship between free energy change and equilibrium; Rates of chemical reactions (first-and second - order reactions); Arrhenius equation and concept of transition state; Mechanisms, including SNI and SN2 reactions, electron transfer reactions, catalysis; Colligative properties of solutions.

Unit 4

General characteristics s, p, d, f block elements. Coordination chemistry - structural aspects, isomerism, octahedral and tetrahedral crystal - field splitting of d orbitals. magnetism and colour of transition metal ions; Sandwich compounds, metal carbonyls and metal clusters, non-stoichiometric oxides; Radioactivity and transmutation of elements; Isotopes and their applications.

Unit 5

IUPAC nomenclature of simple organic and inorganic compounds; Concept of chirality - recognition of symmetry elements and chiral structures, R-S nomenclature, diastereoisomerism in acyclic and cyclic systems, E-Z isomerisms; Conformational analysis of simple cyclic (chair and boat cyclohexanes) and acyclic systems; Interconversion of Fischer, Newman and Sawhorse projections.

Unit 6

Common organic reactions and mechanisms - reactive intermediates; Formation and stability of carbonium ions, carbanions, carbenes, nitrenes, free radicals and arynes; Nucleophilic, electrophilic, radical substitution, addition and elimination reactions; Familiar name reactions - Aldol, Perkin, Stobbe, Dieckmarn condensations; Hofmann, Schmidt, Lossen, Curtius, Beckmann and Fries rearrangements; Reimer - Tiemann, Reformatsky and Grignard reactions; Diels - Alder reactions; Clasien rearrangements, Friedel-Craft reactions, Wittig reactions,

Robinson annulation; Routine functional group transformations and interconversions of simple functionalities; Hydroboration, Oppenauer oxidations, Clemmensen, Wolff- Kisluler, Meerwein-Ponndorf-Verley and Birch reductions.

Unit 7
Elementary principles and applications of electronic, vibrational, NMR, and mass spectral techniques to simple structural problems.

Unit 8
Chemical laboratory techniques: Precautions in handling toxic chemicals and hazardous reactions; Solvent purification and drying, extraction, distillation, crystallization, sublimation, separation methods; Functions of common equipments, water and oil pumps, heating and cooling baths, stirrers, rotary evaporators, good laboratory practices (GLP).

Unit 9
Introduction to agrochemicals; Classification, IUPAC nomenclature, structure, properties, mode of action and uses of major conventional synthetic and natural agrochemicals including plant production chemicals; Safety aspects, pesticide poisoning and antidotes; Production, consumption and trade statistics of pesticides and fertilizers; General aspects of pest and pesticide management.

Unit 10
Agrochemicals - regulation, quality control and management; Laws, acts and rules governing registration and regulations of agrochemical production and use; Acts and regulations promoting social security and welfare of workers; EPA, WHO, FAO, CODEX and national/international guidelines; Regulatory aspects as per Insecticide Act, Quality Control, Sanitary and Phytosanitary standards.

Unit 11
Agrochemical formulation - classification, formulation codes ; Solid and liquid formulations; preparation, properties, specifications and uses; Formulants - carriers/ diluents, surfactants, synergists, safeners, encapsulants, binders, anti-oxidants, stabilizers; Application - devices and quality of deposits.

Unit 12
Pestiside residue chemistry; Pesticide residues - concepts and toxicological significance; Experimental design, sampling, principles of extraction and clean-up from different substrates; Application of spectrophotometric, chromatographic, ELISA and radiotracer techniques/methods in pesticide residue analysis; Confirmatory techniques; Multi-residue methods; Bound and conjugated residues; Method validation - linearity, LOD and LOQ, abiotic and biotic transformations, microbial and photochemical degradation, adsorption/desorption, leaching in soil, modeling of pesticide fate in the environment.

Unit 13

Chemistry of plant nutrients - essential plant nutrients (major, secondary and micro); Organic manures (farmyard manure, compost, sewage, sludge, green manure, biogas slurries, etc.); Production, manufacture and uses of various nitrogenous, phosphatic, potassic and complex fertilizers and fertilizer mixtures, liquid fertilizers, biofertilizers; Integrated plant nutrient management; Nutrient use efficiency (principles and approaches); Soil conditioners and amendments.

Unit 14

Application of chemical principles and knowledge in the field of Nanoscience and Technology, Chemoinformatics, Biotechnology and Genetic Engineering, Combinatorial Chemistry and Pesticide discovery.

Unit 15

Data analysis: Types of errors, accuracy and precision, least-squares analysis, analysis of variance, correlation; Hest, chi-square (X^2), F test.

45. HOME/ FAMILY RESOURCE MANAGEMENT

Fundamentals and theories of human development, population dynamics and family welfare, marriage and family dynamics, children with special needs, methods and techniques of assessment in human development, trends and issues in early childhood care and education, guidance and counseling.

Unit 1 : Textile Science and Care

Processing/manufacturing, properties of natural and man-made fibers; classification, characteristics, structure and uses of yarns; blends and mixtures (principles, type and technology); methods of fabric construction (weaving, knitting, lace making, felts and non-woven); principles of weaving, basic weaves, loom and its parts; basic weaves (plain, twill and satin), decorative/fancy weaves (jacquard, dobby, leno, double cloth, warp and weft figuring, pile weave); knitting (principles, classification and knitting machines); dyes and pigments, classification of dye, dyeing techniques (solution dyeing, fibre dyeing, yarn dyeing, piece and garment dyeing), resist dyeing, methods of printing (block, screen, stencil, roller, transfer printing and batik), technological advances in dyeing and printing; finishes; Principles and methods of washing and finishing; Stain removal; care and storage of clothes.

Unit 2 : Garment Manufacturing, Fashion, Retailing and Merchandising

Anthropometric measurements (importance and techniques); sewing machine (parts, their uses and care); clothing construction (basic principles of drafting, flat pattern and draping methods), flat pattern making, principles of pattern making, draping; standards, grading and alteration of basic block; importance and functions of clothes; clothing requirements for infants, toddler, pre-school, elementary school children, adolescents, adults and senior citizens; social, economic and psychological factors affecting clothing choices; factors determining fashion trends; fashion cycle and terminology; role and importance of textile and garment industry in Indian economy; textile policy under five year plan; marketing of textiles and clothing (channels of distribution-manufacturer, wholesalers, retailers, middleman, their functions and methods of selling); terminology, concept and principles of retailing and merchandising; techniques of retailing and merchandising of textiles and apparel industry; marketing trends (assessment of market trends, forecasting and significance in product planning); Price determination (different methods of pricing); export and import procedure and policies; sale promotion techniques; status of textile and apparel industries in the global scenario.

Unit 3 : Textile Designing, Quality Analysis, Traditional Textiles and Costumes

Woven designs (simple and compound structures of fabric), decorative designs (naturalistic, conventional, abstract and geometric designs); elements of design and application of various design principles in textile designing; design repeats; use of CAD in textile industry; importance of textile and apparel testing; textile performance standards and various organizations associated with textile testing and quality control; fibre testing; yarn testing; fabric testing; qualitative and quantitative estimation of blends and mixtures in textiles; Assessment of colourfastness of dyed textiles. origin of costumes; historical background of Indian costumes; traditional textiles and costumes of different states of India; factors affecting diversity of textiles and costumes of India (geographical factors, socio-economic factors, customs, traditions and religious factors).

Unit 4 : Fundamentals and Theories of Human Development

Stages of human development (prenatal development stage, infancy, early childhood, middle childhood, adolescence, early and middle adulthood, old age and maturity). Physical, emotional, intellectual, social, moral, language and personality development. Principles of human growth and development. Role of family, school and peer interaction in the development of the child. Theories of child/human development with special reference to cognitive development theories. Developmental tasks at different stages. Methods and techniques of assessment in human development.

Unit 5 : Population, Family Dynamics and Family Welfare

Demographic profile of child in India. Theories of population education; growth of population in world and India, socio-cultural aspects of population growth in India, population policies in India. National and international organizations/programmes like ICDS, FPAI, WHO, UNICEF, CARE, UNFPA, USAID, UNESCO, UNDP, IFAD, IMF and ILO. Government development programmes for population, women and children in India. Concept of family, family composition and structure; social changes affecting the family. Causes and effects of family disharmony. Status of women in India, rights of women and children, national policy for children, national commission for women. Marriage - concept and meaning. Readiness for marriage-physiological, social, psychological and others. Premarital association, premarital guidance and councelling. Approaches to study family-developmental social, psychological and educational. Family planning. Legal aspects: laws regarding marriage, adoption, divorce, inheritance. Children with special needs (types of impairments: physical, visual, auditory, mental retardation, cerebral palsy, speech defects, and learning disabilities). Special education for children with developmental challenge. Trends and issues in early childhood care and education. Parent and community education.

Unit 6 : Family Resource Management and Consumer Science

Interdisciplinary nature of management and systems approach to family resource management. Theories and concept in family resource management. Goal types and goal setting, value types, sources of learning values and their importance to family, standards- types and relationship with values and goals. Resources- types, characteristics, and factors affecting use. Needs and wants. Process of management. Decision making process. Application of management process to time and energy for work simplification. Fatigue- meaning, types, causes, effects and remedies. Techniques of time and motion studies and application of Mundel's classes of change in household work, agricultural and allied tasks.

Household energy forms. Energy crisis, its causes and implications for energy management in homes. Equipment, tools and accessories for rural and urban houses. Types of money and function, family income (types, sources, contribution and methods of handling family income).Guidelines for budgeting. Banking, e-banking and insurance. Credit. Consumer rights, Consumer Protection Act and other laws. Grading, standardization and packaging. Public distribution system. Basic Economic laws- demands, supply, consumer surplus, price index, inflation, deflation, income distribution. Taes. Cost of living, standard of living, factors affecting standard of living. Types of market, their functions. Sales management and product promotion. Consumer goods- types, buying motives. Channels of distribution. Consumer retail services.

Advertising. Price determination. International trade, World Trade Organization. Right to information.

Introduction to ecology and environment. Man, environment and resources, micro and macro environment, family as an ecosystem, impact of environment on family life, environment and health hazards due to pollution. Concepts of sustainable development and household and farm waste and waste utilization techniques. Environmental education in India.

Importance and scope of entrepreneurship. Basic concepts and characteristics of an entrepreneur. Women entrepreneurship development. Role of government and private organization in financing. Role and functions of small-scale industries, KVIC, DRDA, DIC, voluntary organizations, state and central level agencies.

Unit- 7. Art principles, Housing and Space Designing

Elements and principles of art and their application in interior decoration. Design and its type. Colour-its importance in interior decoration, colour theories, colour schemes and their application in interior decoration. Furniture- types, selection, arrangement, care and maintenance. Household furnishing-types, selection, care and maintenance. Wall treatments, window types and window treatments. Floor and floor coverings. Lighting-functions, natural and artificial light. Flower arrangement, tools and accessories used.

Identifying family housing needs and future projections. Selection of site-orientation and zoning. Factors to be considered in house planning. Drawing house plans for different income groups and activities. Different types of houses, economic house construction. Building materials. House ownership. Housing finance-source and cost. Government/semi-government housing schemes/programmes. Rain water harvesting.

Work, worker and work place relationship. Human costs of work in relation to affective, cognitive, temporal and physical components. Functional design and arrangement of work places for different occupational activities. Ergonomic designing of furniture and equipment. Determining physiological cost of work. Planning interiors for people with special needs.

46. AGRICULTURAL ECONOMICS

Unit 1 : Agricultural Development and Policies

Role of agriculture in economic development; growth and development, characteristics of developing and developed economies; theories of development; role of economic, technological, social, cultural, political and environmental factors; interdependence between agricultural and industrial development; growth models - Harrod-Domar, neo-classical, Von Neumann; development strategies in India; five-year plans and agriculture.

Agricultural growth analysis - determinants of agricultural growth and their measurements; planning models, features of planning in capitalist, socialist, neo-socialist and mixed economies; types of planning - micro level, regional, sectoral, agro-eco regional development; role of non-government orgnisations (NGOs) and self help groups (SHGs) in agricultural development; characterizing agricultural growth, changes in cropping pattern, decomposition analysis and sources of output growth; analysis of instability; capital formation, crop livestock insurance, infrastructure; transfer of technology - constraints to technology adoption, yield gap analysis and research planning; agricultural information system.

Agricultural policy analysis and reforms - energy, water, fertilizer, land, seed, labour, technology, rural infrastructure, marketing, pricing, trade etc.

Concepts of food security, production oriented policies, food price policies, food subsidies, food safety net and food quality. Measurement of poverty, poverty alleviation programmes.

Unit 2 : Natural Resource Management

Characteristics and classification of natural resources; sustainability issues in natural resources; role of economics in natural resource accounting, planning, management and policy formulation; social welfare function; allocation of renewable and non-renewable resources (forests, water, land, etc.) under various market structures: management strategies for major natural resources; Government programmes for conservation and development of natural resources.

Unit 3 : Farm Business Management and Production Economics

Basic principles of farm management - marginal returns, opportunity cost, cost substitution, equimarginal returns, enterprises combination, time comparison and comparative advantage; cost concepts and analysis; farm efficiency measures; farm financial analysis; farm planning and budgeting; book keeping and accountancy; process of decision making under different knowledge situations; measurement and management of risk and uncertainty in agriculture (including livestock, horticulture, fisheries, forestry, etc.), diversification and insurance in agriculture and allied sectors.

Forms and applications of production functions - linear. quadratic. square root, spillman, cubic, semi-log, Cobb-Douglas, constant elasticity of substitution (CES), variable elasticity of substitution (VES), etc; dualities between production, cost and profit functions; derivation of supply and factor demand functions from production and profit functions; optimization of resource allocation; product-product relationships; resource-enterprise organization; resource-use

efficiency and returns to scale; frontier production function; total factor productivity; rainbow (green, white, yellow, blue, etc.) revolution.

Unit 4 : Agricultural Finance

Importance of agricultural finance; rural credit structure-demand, supply, sources and forms; estimation of credit requirement; cost of credit/capital; credit appraisal- 3 Rs and 3 Cs of credit; reforms in agricultural credit policy; innovations in agricultural financing - microfinance, kisan credit cards; role of institutions in agri-finance - public and private sector banks; cooperatives, micro-finance institutions (MFIs), SHGs; international financial institutions; principles of agricultural financial management; successes and failures of co-operative sector in India; Role of co-operatives under emerging economic scenario; agricultural project analysis; Internal Rate of Return (IRR), Benefit Cost (B-C) ratio analysis.

Unit 5 : Agricultural Marketing and Price Analysis

Marketing in a developing economy; structure, conduct and performance analysis; marketable and marketed surplus; marketing functions; processing, transportation, storage and warehousing; forward trading, futures market; and commodity, boards; channels in marketing, price spread and efficiency; problems in marketing agricultural produce; government interventions including regulated markets, procurement, buffer stock operations, co-operative marketing etc.; demand and supply models- formulation, estimation and projections; marketed surplus models: marketing of agricultural inputs; market integration; price stabilization measures and policies.

(B) AGRI-BUSINESS MANAGEMENT

Unit 6: Organizational Behaviour and Human Resource Management

The agribusiness system; management processes, planning, controlling, organizing, motivating and leading; decision making; managerial skills; level of managers; organizational context of decisions; decision making models; management by objectives; organizational culture; management of organizational conflicts; managing change; leadership styles; group dynamics; motivation.

Human resource planning, job analysis and design; recruitment, selection, induction and placement; human resource training and development; management development; performance appraisal and job evaluation; wagc and salary administration; promotion, transfer, separation, absenteeism and turnover, employee welfare and safety; morale; personnel supervision; styles; participative management; labour management relations; negotiation and negotiating skills; conflict management.

Unit 7 : Financial Management

Fundamentals of accounting and book-keeping; objectives and functions of financial management; analysis of financial statements- balance sheet, income statement, cash flow statement; capital structure theories; sources of long term finance and cost of capital; concepts of components of working capital, managing working capital - cash management, dividend decision; capital budgeting, appraisal criteria; agribusiness financing system in India-money and capital markets, national, regional and global financial institutions; rural insurance; risk management; micro-credit.

Unit 8 : Marketing Management

Indian marketing environement; rural marketing; agricultural marketing system, wholesaling and retailing, consumer behaviour; the buying process; marketing mix; marketing strategy; planning marketing mix; market segmentation; land targeting: marketing organization, marketing information system, market research, marketing extension; rural retailing; international marketing and finance.

Unit 9: Production and Operations Management

Operations management of an agro-industrial unit including operations system and processes; productivity of operations; work force productivity; facilities management; operations planning and control; material and supply chain management; quality management.

Unit 10 : Strategic Management

Strategic management – meaning, concept and scope; framework for strategic management; industrial (external) and organizational (internal) environmental factors influencing strategy; scanning the external and internal environment; strategy formulation; SWOT analysis; strategy implementation; strategy and structure, strategic analysis, strategy and technology, strategy and leadership, total quality management, the customer resource, development of strategy, creating competitive advantage strategy, evaluation of strategy.

Unit 11 : Entrepreneurial Skills and New Venture Planning

Entrepreneurship and small business concepts; process of business opportunity identification; project feasibility study; detailed business plan preparation; managing small enterprises; planning for growth; sickness in small enterprises; government policies for promotion of small and tiny enterprises; rehabilitation of sick enterprises; entrepreneurship.

47. AGRICULTURAL EXTENSION

Unit 1 : Fundamentals of Agricultural Extension and Communication

Concepts of agricultural extension and communication. Historical and emerging perspectives of agricultural extension in India and other countries. Conceptual and philosophical similarities and differences among extension education, adult education and continuing/distance education. Scope and role of agricultural extension / home science extension / veterinary and animal husbandry extension / dairy extension and fisheries extension in rural development. Farming System Research and Extension (FSR&E) and participatory development approaches. National Agricultural Extension System and networking of state development departments, State Agricultural Universities, Indian Council of Agricultural Research, NGOs, cooperatives and private organizations. Human behavioral dimensions related to agricultural extension; Concepts of teaching and learning process - principles of learning as applied to agricultural extension. Understanding of basic rural institutions, social structure, culture and norms. Social and technological change processes, group dynamics, concept and theories of rural leadership, concept and models of communication, credibility, fidelity, empathy and feedback in communication. Concept and stages of Innovation - Decision Process. Innovation attributes and consequences of Innovations. Concept and elements of diffusion and adoption, adopter categories.

Unit 2: Information Communication Technologies in Agricultural Extension

Concept of Information Communication Technology and its role in agricultural development. Extension teaching methods and audio-visual aids; classification, selection and use. Information Communication Technologies - print and electronic media, e-mail, Internet, use of multimedia, video and teleconferencing, computer-assisted instructions, touch screens, micro-computers and web technologies. Networking system of information, problems and prospects of Information Communication Technologies. Interpersonal and mass communication methods. Basics of agricultural journalism, types of publications – bulletins, folders, leaflets, booklets, newsletters, popular and scientific articles. Information Kiosks. Agricultural Technology Information Centers (ATIC). Technology Parks. Management Information System in agricultural extension. Management of Agricultural Knowledge System (MAKS) and use of Expert System in agricultural extension.

Unit 3: Agricultural Extension Management

Concept of administration and management. Principles of administration and management, scientific management movement, classical and modern theories of management, schools of management thought. Functions of management – planning, organizing, staffing, directing and leading, controlling, coordinating, reporting and budgeting. Monitoring and evaluation. Types and methods of administrative communication. Decision-making in organization. Organizational effectiveness, organizational climate, organizational behaviour, organizational development. Coordination at different levels of extension management, methods of coordination. Management by Objective (MBO). Project Evaluation and Review Technique (PERT). Logical Frame Working (LFW) and Project Management Techniques. Personal management, scope of Agri Business Management and Institutions - National Institute of Agricultural Extension and Management (MANAGE). Indian Institute of Plantation Management (IIPM), NIRD, EEl and NAARM. Monitoring, evaluation nnd impact analysis of extension programmes.

Unit 4: Research Methodology in Extension Education

Social research and types of research. Science and scientific approach. Characteristics of scientific method. Theory and Fact. Selection and identification of research problems, methods of data collection- interview method and mailed questionnaires, variables - meaning and types, independent, dependent and intervening variables. Hypothesis – concept, characteristics, types and testing of hypothesis. Research design - concept and types of research design, ex-post facto and experimental design, field studies, case studies and survey method. Action Research and participatory research. Measurement – meaning, levels of measurement. Methods of sampling and statistical tests. Reliability and validity of tests, normal distribution, tests of significance, ANOVA, correlation and regression, scaling techniques. Processing of data, coding - tabulation. analysis and interpretation. Writing of scientific reports, citing references. Participatory approaches, PRA, RRA, PLA and PTD.

Unit 5 : Agricultural Human Resource Development

Human resources and their importance in agricultural development. Concepts of human resource and human resource management. Training and development of human resources. Training process (capacity building). Phases of training - pre training, during training and post training. Developing training modules, training requirements, training methods. Lecture cum demonstration method, case method, group brain storming, syndicate method, business games, simulation exercises, in basket exercise, programmed instruction, experiential learning techniques such as sensitivity training, T-group, transactional analysis and fish bowl exercise. Entrepreneurship development - agriclinics and agribusiness centers. Capacity Building in relation to Dairying, Poultry, Piggery, Goat and Sheep farming, cottage industries, Rabbit farming, Apiculture, Sericulture, Biofertilizer, Floriculture, and Biopesticides. Evaluation of training - types and techniques of training evaluation. Motivation, stress management and organizational behaviour as facilitators of human resource development. Performance appraisal - concept and types.

Unit 6 : Developmental Strategies and Issues in Agricultural Extension

Issues related to extension policies and developmental strategies. Developmental strategies such as Watershed Development Programmes; Technology Mission, Horticulture Mission. Front Line Extension Programmes of ICAR/TAR-IVLP, NATP, NAIP, IRDP, ATMA, ITD, SREP, Research-Extension-Farmer-Interface. Identification, characterization, documentation and validation of ITKs. Privatization of extension, market led extension, production to consumption and end to end innovative approaches. Issues related to globalization and IPR. Self Help Groups – concepts, organisation, mobilization, micro-finance and functioning of SHG for empowerment and sustainability. Rural, Agricultural, Animal Husbandry, Dairy and Women Developmental Programmes implemented by Govt. of India. Gender Issues - women in Agriculture and their empowerment. International cooperation in agriculture - SAIC, Common wealth, FAO, USAID, DFID and CGIAR system. Concepts of yield gaps. FLD and OFT in relation to TOT programmes. Agricultural Extension in the context of enhancing productivity, Quality, Nutrition, Profitability, Income and Employment.

48. HOME SCIENCE EXTENSION

Unit 1 : Fundamentals of Extension Education

Home Science extension education: concept, principles, philosophy, objectives and approaches. Growth of extension as a discipline and profession. Genesis of rural development programmes in India. Community Development and Integrated Rural Development- concept, principles and objectives. Relationship between family and community development. Gender sensitivity in extension education programmes.

Unit 2 : Rural Institutions and Organisations

Structure, types and functions of rural institutions, process of activising them, and factors influencing their involvement in rural development. Leadership-concept, types, identification, training and mobilizing local leaders for community participation. Problems of women leaders. Panchayati Raj-philosophy, concept, functioning and scope.

Unit 3 : Programme Planning and Evaluation

Concept, steps, principles and theories of programme planning. Application of programme planning for Home Science Extension through PERT and CPM. Evaluation – concept, significance, methods and tools for monitoring and evaluation. Theoretical models of programme planning. Five Year Plans – critical analysis with special reference to programmes for women, children and youth. Development programmes, *viz*. Integrated Child Development Services (ICDS), Integrated Rural Development Programme (IRDP), Development of Women and Children in Rural Areas (DWCRA), Training of Rural Youth for Self Employment (TRYSEM), Krishi Vigyan Kendras (KVKs). Role of Non-governmental Organizations (NGOs) in extension, SWOT analysis of development programmes.

Unit 4 : Extension Management

Meaning, nature, principles, process, functions and scope of administration, supervision and management. 'POSCORD' – planning, organizing, staffing, directing coordinating, reporting and budgeting. Critical analysis of organizational set up of extension administration at various levels. Training – principles, importance, methods and factors affecting extension training. Identifying training needs and assessment of training impact.

Unit 5 : Entrepreneurial Development

Concept, significance and scope. Programmes and agencies promoting women as entrepreneurs. Types and techniques of training for developing entrepreneurial activities in Home Science areas. Self Help Groups- concept, organization, mobilization and functioning of SHGs for sustainability. Human Resource Development- concept, need and strategies.

Unit 6 : Extension Methods and Communication Techniques

Extension methods and audio-visual aids. Characteristics of adult learning. Teaching-learning process in extension. Individual, group and mass approaches in extension, audio-visual aids- classification, selection, use and production of audio-visual aids. Traditional media for communication in development programmes. Modularized communication- concept, approach, need , process of designing instruction for transfer of communication.

Unit 7 : Communication for Development

Concept, functions, key elements, theories and models of communication. Barriers to communication. Concept and models of development. Diffusion and adoption for social change- concept, process, models and theories. Revolution in communication strategies. Advanced techniques in mass communication and soft-ware production. Participatory communication – theories and models, designing and developing participatory massage. Concept, need and constraint of community based learning.

Unit 8 : Research Methods in Home Science Extension

Need for social science research. Process and designs of scientific research. Measurement, levels of measurement and corresponding statistical techniques. Validity and reliability of measuring devices. Methods of observation and data collection. Techniques of tabulation and analysis of data. Participatory research methods, techniques and tools. Report writing.

Unit 9 : Social Statistics

Sampling techniques. Normal distribution. Parametric and non-parametric statistical tests. Correlation and regression – simple, partial and multiple. ANOVA. Path analysis. Factor analysis.

49. VETERINARY EXTENSION

Unit 1 : Fundamental of Extension Education

Development of extension education in India and abroad as a discipline and a profession. Concept, definition, philosophy, principles and scope of extension education in livestock development. History of veterinary extension programmes developed and implemented by IVRI, NDRI and other institutions and organizations. Similarities and differences between formal and informal education; Extension service and Extension Education. Importance of study of veterinary extension by veterinarians, animal husbandry and dairying students. Specific aims, objectives and philosophy of veterinary extension. Agricultural extension vs. veterinary extension. Role of subject matter specialists in extension service. Relationship of extension education with other social sciences. Role of veterinarian as a social scientist. Role of extension education in development and socio-economic upliftment of vulnerable sections of the society. Special animal husbandry promotion programmes i.e., Operation Flood in its historical perspective, ICDP, Key Village Scheme, Gaushala Development Scheme, and T&V system; TOT projects of ICAR. Approaches and models of extension education. Extension systems in State Agricultural Universities, State Depts with special reference to animal husbandry and veterinary services. Development of efficient linkages between research and extension; challenges and problems in promotion of veterniary extension in rural areas. Farming Systems Research. Participatory Extension. Technology development in veterinary science – technology assessment and refinement possibilities. Role of village community in veterinary extension services.

Unit 2 : Communication, Diffusion and Adoption of Innovations

Definition, concept, nature and scope of communication for animal husbandry and dairy development, models and elements of communication, types of communication media and their utilization for specific jobs related to veterinary extension activites. Interpersonal, group, and mass communication. Utilization of Internet for promoting advanced veterinary and animal husbandry practices; communication with rural, semi-urban and urban livestock owners. Acquiring communication skills for development of local leaders and key communicators for livestock development. Rapport building with clientele. Source credibility, communication fidelity and empathy. Organizational communication. History taking and follow-up appraisal on prognosis and treatment of sick animals. Problems and barriers in communication; distortion and noise in communication. Importance of feedback in veterinary extension.

Diffusion process, adoption process, models of diffusion and adoption, adopter categories and their characteristics. Factors influencing adoption, attributes of innovations. Diffusion of veterinary and animal science innovations. Important researches in veterinary extension with reference to communication, diffusion and adoption. Gaps and constraints in adoption.

Unit 3 : Research Methodology

Scope and nature of social science research, research process. Biases in research. Hypotheses, its forms and importance; formulation of null hypotheses and its testing. Drawing of scientific inferences. Nature and types of variables. Sampling versus complete enumeration. Sampling from a finite population, estimation of sample size, simple random, stratified random, systematic, purposive, two stage, multi-stage, and cluster sampling. Sampling errors. Methods of data

collection. Steps involved in the conducting of surveys. Pilot studies. Techniques for preparation of interview schedule, questionnaire, observations, and case studies. Surveys in the field of animal husbandry and dairaying, social-economic surveys. Tabulation of data, analysis of qualitative data. Introduction to scaling techniques. Participatory Learning and Action and PRA techniques as used in veterinary extension. Social science research designs: ex-post-facto- and experimental studies. Reliability and validity.

Unit 4 : Extension Methods and A-V. Aids

Understanding teaching-learning process. Cone of experience. Learning experience, capacity, ability. Attributes of adult learners. Extension teaching methods: Individual, group and mass approach. Selection, planning and use of different extension teaching methods like demonstration, exhibition, farmers fairs, field days, tours, extension literature, etc. Preparation and presentation of different projected and non-projected audio-visual aids. Public speaking. Planning, production and use of audio/video cassettes. Preparation of radio/video script. Selection of effective extension teaching methods individually and in combination. Handling and operation of different audio-visual aids and equipments. Principles of photography and its use in veterinary extension.

Unit 5 : Veterinary Extension Management

Definition of management, theories of management, models of management; need hierarchy, work motivation, organizational communication. Decision making. Nature and types of leadership; conflicts in organizations. Individual and group behaviour. Organizational climate and organizational renewal. Organizational development. Personnel management in animal husbandry organization. Management of common property resources. Improving supervison; job satisfaction and morale. Time use management. Performance appraisal.

Unit 6 : Rural Sociology

Definiton, concept, scope and its relation with other social sciences. Concept of social systems and their major elemental and master social processes. Rural social systems as differentiated from urban social systems. Concept of culture. Social structure. Groups, primary, secondary and reference groups; Social stratification; basic rural social institutions – family, kinship, marriage, rural educational institution, panchayat, co-operatives etc. and their role in animal husbandry development. Socialization and social control. Social change and animal husbandry development. Factors affecting social change in rural areas, indicators and types of social change. Role of women in animal husbandry development. Importance of indigenous knowledge in animal husbandry and veterinary science.

Unit 7 : Programme Planning for Livestock Development

Singificance, concept and principles of programme planning. Steps in programme planning for livestock development, organizing campaigns, mass vaccination programmes and variety of extension activities, evaluation of veterinary extension programmes, compilation and report writing. Evaluation of animal husbandry development programmes and schemes. Programme planning from top to down and bottom to up. Felt needs; need-based programmes. Social action. Critical review of five year plans with respect to veterinary science and animal husbandry.

Concept of training and education and their inter-relationship. Scope and importance of training. Historical background and present status of training programme in various institutions and organizations in India, particularly for farmers, farm women and rural youth. Concept and working of T&V system. Types of training and factors affecting training.

50. AGRICULTURAL STATISTICS

Unit 1: Statistical Methods I

Descriptive statistics. Elements of probability theory, conditional probability, Bayes' theorem. Random variable –discrete and continuous. Mathematical expectation. Moment generating and characteristic functions. Laws of large numbers. Central limit theorem. Discrete probability distributions – binomial, Poisson, negative binomial and hypergeometric. Continuous probability distributions – normal, rectangular, Cauchy, exponential, gamma and beta. Sampling distributions – chi-square, t, and F. Bivariate normal distribution –conditional and marginal.

Point estimation – unbiasedness, consistency, efficiency, sufficiency. Completeness, Minimum variance unbiased estimator. Cramer-Rao Inequality. Rao-Blackwell theorem and Lehman-Scheffe theorem. Methods of point estimation like Maximum likelihood, Moments, Minimum chi-square. Confidence interval estimation. Testing of hypotheses – two types of errors, level of significance and power of a test. Neyman-Pearson Lemma. Uniformly most powerful tests and their construction. Unbiased test, Likelihood ratio test. Tests of significance based on Z, t, chi-square and F distributions.

Unit 2: Statistical Methods II

Correlation, rank correlation, correlation ratio, intra-class correlation. Simple and multiple regression analysis, partial and multiple correlation. Examination of residuals. Model-adequacy, Selecting best regression. Order statistics. Non-parametric tests – run, sign, rank, Wilcoxon, Kruskal-Wallis, Mann-Whitney, Cochran and Friedman's tests. Contingency tables. Log linear models. Sequential analysis – sequential probability ratio test. Elements of stochastic processes. Multivariate normal distribution – estimation of mean vector and dispersion matrix. Wishart distribution, Hotelling T^2, multivariate analysis of variance, principal component analysis, factor analysis, discriminant analysis, cluster analysis.

Unit 3: Statistical Genetics I

Statistical analysis of segregation, detection and estimation of linkage. Gene and genotypic frequencies. Random mating and equilibrium in large populations. Disequilibrium due to linkages for two pairs of genes and for sex linked genes. Selection, mutation and migration. Equilibrium between forces in large population. Polymorphism. Fisher's fundamental theorem of natural selection. Polygenic systems for quantitative characters, Concepts of breeding value, dominance, average effect of gene and epistatic interactions

Unit 4: Statistical Genetics II

Genetic variance and its partitioning. Correlation between relatives. Regular system of inbreeding, effects of inbreeding. Genotype and environment interaction, stability parameters. Estimation of heritability, repeatability and genetic correlation. Path coefficient analysis. Heterosis, concepts of general and specific combining abilities. Diallel crosses and line × tester analysis. Response due to selection. Prediction of response to individual, family and combined selections. Construction of selection index.

Unit 5: Design of Experiments I

Linear models – Random, fixed and mixed effects. Nested and crossed classifications. Gauss-Markoff theorem. Analysis of variance. Principles of design of experiments. Uniformity trials. Completely randomized design. Randomized complete block design. Latin square design. Factorial experiments – $2^n$and 3^n series and asymmetrical factorial experiments, confounding in 2^n and 3^n experiments, split and strip-plot designs, change over designs. Missing plot techniques. Analysis of covariance. Variance stabilizing transformations.

Unit 6: Design of Experiments II

Balanced incomplete block designs and their analysis with and without recovery of inter block information. Partially balanced incomplete block designs with two associate classes, lattice designs. Youden square design. Multiple comparison procedures. Fractional replication of symmetrical factorials, confounding in asymmetrical factorial experiments. Response surface designs, second order rotatable designs. Combined analysis of groups of experiments. Sampling in field experiments. Experiments on cultivators' fields.

Unit 7: Sample Surveys I

Sampling versus complete enumeration. Concept of probability sampling. Simple random sampling. Stratified sampling, allocation in stratified sampling, choice of strata, construction of strata boundaries and collapsing of strata. Use of auxiliary information in sample surveys, ratio and regression methods of estimation. Systematic sampling. Cluster and multi-stage sampling with equal probability.

Unit 8: Sample Surveys II

Sampling with unequal probabilities with and without replacement, sampling schemes with inclusion probabilities proportional to size. Unbiased ratio type of estimators, Double sampling, sampling on successive occasions, inverse sampling. Non-sampling errors –sources and classification. Non-response in surveys – interpenetrating sub-samples, randomized response techniques, imputation methods. Design and organization of pilot and large scale surveys. National sample surveys. Agricultural statistics system in the country – land use statistics, crop estimation surveys, livestock and fishery statistics.

Unit 9: Computer Applications

Computer Organization and Architecture- number system, input/output unit, memory, arithmetic logic unit and control unit.

Computer algorithms. Programming in C-Building blocks, control structures, arrays, pointers, dynamic memory allocation, file management. Data Structures – linked list, stack, queue, tree, graph, sorting and searching algorithms. Data Base Management System – definition and features, data models, relational database. Object oriented programming – encapsulation, inheritance, polymorphism with C++/JAVA. Networking – need, basic concepts, types of networks. Connecting computers – local area networks, wide area networks. Value added network services –E-mail, on-line services, Internet, etc. Hyper Text Markup Language (HTML), Building static and dynamic web pages.

Numerical analysis – interpolation, numerical integration, solution of ordinary differential equations, solution of linear and non-linear system of equations. Modeling and simulation – random number generation and testing, discrete simulation models, simulation of stochastic events and processes, design of simulation experiments, analysis of data generated by simulation experiments, validation of simulation models. Linear Programming – formulation and graphical solution, simplex method, duality, transportation and assignment problems.

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51. FARM MACHINERY AND POWER

Unit 1: Farm Mechanization and Equipment

Status of farm mechanization in India. Power availability on farm. Hand tools used for different kinds of farm operations and materials for construction. Functional requirement, principle of working, constructional features and operation of animal and power operated equipment for tillage, land development, sowing, planting, fertilizer application, intercultivation, plant protection, harvesting, threshing, mowing, chaff cutting and baling. Special equipment for crops such as sugarcane, cotton, groundnut, potato and plantation crops like coconut, areca nut, cashew nut etc.

Unit 2: Farm Machinery Design

Selection of machinery elements *viz.* gears, pulleys, chains and sprockets, belts, bearings, couplings and springs. Force analysis on agricultural tools and implements, pull, draft, unit draft and power calculation of animal and power operated implements. Design of soil working tools for sowing and planting. Design of fertilizer applicators, intercultivation equipment, harvesting and threshing machineries, forage harvesters and chaff cutters.

Unit 3: Farm Machinery Testing, Evaluation and Management

Calibration of seed drills, planters, plant protection equipments. Method of testing and performance evaluation of tillage equipments, seed drills and planters, fertilizer applicators, sprayers and dusters, harvesting and threshing equipments, grain and straw combines, and special equipment such as sugarcane, cotton, rice and potato planter. Calculations of field capacity, efficiency and rates of seed, fertilizer and chemical applicators. Calculation of capacity, efficiency and losses in threshers, harvesters and chaff cutters. Farm machinery selection and management for different soils, crops and operations. Cost analysis of animal and tractor operated implements and tractors.

Unit 4: Engines and Tractor Systems

Engineering thermodynamics, power cycles, fuels. Various systems of spark and compression ignition engines. Operations, adjustment and trouble shooting for working of different systems. Calculations of power, torque, speed, firing arrangement and intervals, heat load and power transmission from piston to the flywheel.

Tractor power transmission, differential, final drives. Power outlets such as P.T.O. and drawbar. Recent trends in tractor design. Mechanical and power steering. Tractor chassis mechanics. Hitching systems, hydraulic controls for tractors, automatic position control and draft control. Tractor performance tests. Operation and maintenance of power tillers.

Unit 5: Ergonomics and Safety

Anthropometry in equipment design, physiological cost and effect of work on physiological responses and comfort. Ergonomics in design of farm tools. Safety aspects of agricultural machinery. Effect of noise and vibration on work performance. Chemical hazards and control measures. Operator's protective gadgets. Design of tractor controls *viz*., hand and foot controls, visual range and limitations, seat design etc.

Unit 6 : Soil Dynamics in Tillage and Traction

Dynamic properties of soil and their measurements. Stress-strain relationships. Theories of soil failure, mechanics of tillage tools. Design parameters and performance of tillage tools. Introduction to traction devices, tyre function and size, their selection, mechanics of traction devices, traction theories, slippage and sinkage of wheels, evaluation and prediction of traction performance. Soil compaction *viz*. causes and methods of alleviation, effect on soil and crop responses.

Unit 7: Renewable Energy Sources

Solar radiation and its measurement. Characteristics of solar spectrum. Solar energy collection and applications. Solar energy storage *viz*. type of storage, sensible heat and latent heat storage, material for storage and storage efficiencies. Solar photovoltaic conversion and SPV powered systems.

Wind power equipments Storage of wind energy. Wind measuring instruments and controls. Types of wind mills, systems of wind mills. Force analysis on wind blades, selection of materials for different parts.

Thermo-chemical conversion of biomass. Direct combustion, pyrolysis and gasification, Sterling engine, chemical conversion process, hydrolysis and hydro-generation. Carbonization, briquetting, palletization and densification of biomass.

Bioconversion of biomass *viz*. Conversion into alcohols, organic acids, solvents of amino acids. Biogas technology, chemistry, physical condition, raw material. Biogas plants and design types, distribution and utilization, properties and their uses.

Unit 8: Energy in Agriculture

Energy sources in agriculture *viz*. conventional and renewable energy equivalents. Energy requirements in agriculture production system. Energy ratio and specific energy value. Inflow and outflow of energy in unit agriculture operation.

Energy Conservation and its status and significances, concept and thermodynamics of energy conservation. Energy conservation techniques for thermal, mechanical and electrical energy. Energy audit, accounting and analysis.

52. AGRICULTURAL STRUCTURES AND PROCESS ENGINEERING

Unit 1: Engineering Properties and Quality of Biomaterials

Uniqueness of bio-materials and physical characteristics *viz*. shape, size, volume, density, porosity, surface areas, friction, rolling resistance, angle of repose. Properties of bulk particulate solids *viz*. specific surface area, mean diameter, flow rate. Aerodynamics drag coefficient and terminal velocity. Pressure drop through packed beds. Thermal properties such as specific heat, thermal conductivity, thermal diffusivity. Dielectric properties *viz*. dielectric and microwave radiation, dielectric constant, energy absorption, heating. Optical properties and transmittance and reflectance.Rheological properties and stress-strain-time relationship, rheological models, visco-elasticity, Hertz's theory of contact stresses.

Food Quality and BIS specifications for quality of food materials, milling quality analysis, cooking and baking qualities. Organoleptic and sensory evaluation of product quality. Determination of protein, oil content, carbohydrates, colour, hardness, texture, nutritive value, bio- availability and microbial loads.

Unit 2 : Post Harvest Unit Operations

Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying, EMC, water activity and psychrometry, size reduction, granulation, crystallization, filtration, evaporation, distillation, mixing, clarification, coagulation, mechanical separation, sedimentation, pressing, expelling, leaching, extraction, palleting and extrusion. Industrial fermentation and processing.

Unit 3: Process Technology and Machinery

Premilling/conditioning treatments. Process technology and machinery for cereals, pulses, oil seeds, fruits, vegetables, flowers, spices, condiments, plantation crops, animal products, sea foods, fiber crops, animal feeds. Seed processing and technology, Agricultural byproducts/residue utilization, Waste disposal of food processing plants, different methods and equipments. Maintenance Engineering.

Unit 4 : Design of Agricultural Structures and Processing Machinery

Functional and structural design of livestock structure, green houses and growth chambers. Design of grain cleaners, graders, dryers, parboiling plants, size reduction machines, bio-reactors, fermenters, centrifuges, cyclones, heat-exchanger, evaporators, filters, extrusion cookers.

Unit 5: Material Handling, Packaging and Transport

Bulk conveying equipments *viz*. belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement, damage to products during mechanical handling. Operation and maintenance of conveying equipments.

Packaging material characteristics and selection. Packaging techniques and equipment for liquid, powder and granular materials, and horticultural produce.

Transportation of food by bullocks, trailers, trucks, rail wagons and containers. Cold chain design and operation. Refrigerated containers and trucks for perishable foods.

Safety standards in handling, packaging and transport of agricultural produce.

Unit 6 : Storage Engineering

Storage environment and its interaction with stored product. Factors/parameters influencing the shelf life of the stored product, climatograph and deterioration index. Modeling of metabolic activities and predication of storage life, quality deterioration mechanisms and their control. Storage practices (including fumigation) and structures (traditional and modern) for food grains. Design of bulk storage and aeration system. Analysis of heat, moisture and gas transfer in bulk storage structures. Bag storage structures, their design and management. Storage of perishables in ventilated, refrigerated, controlled and modified atmosphere storage systems and their design. Quality analysis of stored produce. BIS standards on practices, equipments and design of storage structures and systems for food grains and other commodities.

Unit 7 : Process Plant Design

Plant design concepts and general design considerations, plant location, product and process design, process flow charts, equipment selection, plant layout, functional design of plant building, Plant sanitation, hygienic design aspects and worker's safety and effluent treatment. HACCP (Hazard Analysis and Critical Control Points) and ISO certification for food processing plants. Plant utilities, Plant operation and management.

Unit 8 : Allied Engineering Subjects

Basic laws of thermodynamics, its properties and processes, energy equations, heat, work, heat engine, heat pump and refrigerator and steam table. Modes of heat transfer, heat exchanger. Mass transfer and mass-heat-momentum transfer analogies. Fluid statics, fluid dynamics, continuity equation and Bernoulli's theorem. Infinite series, partial differential equation. Green's theorem. Vectors and matrices.

Unit 9 : Agri-project Planning and Management

Project development. market survey and time motion analysis. Selection of equipments. technology option, techno - economic feasibility. Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation Iog book. Material balance and efficiency analysis, testing performance, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning.

Dimensional analysis and simulation of processing operations. Simulation models and mathematical modeling. Finite element analysis.

53. SOIL AND WATER CONSERVATION ENGINEERING

Unit 1: Groundwater Development, Wells and Pumps

Water resources of India. Irrigation potential and contribution of groundwater, utilisable groundwater resources and level of groundwater development in the country, scope of groundwater development. Aquifer types and parameters. Principles of groundwater flow, interaction between surface and groundwater, natural and artificial groundwater recharge. Hydraulics of fully and partially penetrating wells. Design, construction and development of irrigation wells. Water lifts, pumps and prime movers, well and pumps characteristics, performance evaluation and selection of pumps. Energy requirement in groundwater pumping. Design of centrifugal pumps. Groundwater pollution. Salt water intrusion in inland and coastal aquifers. Application of groundwater models for groundwater development and management. Conjunctive use of surface and groundwater.

Unit 2: Open Channel Hydraulics

Hydraulics of open channel flow, energy and momentum principles, specific energy, Hydraulic jump and its classification. Design of different types of irrigation channels. Irrigation water measurement: using velocity area method, water meters, weirs, notches, flumes, orifices etc. Water conveyance and control. Conveyance losses and lining of irrigation channels. Irrigation water delivery and distribution.

Unit 3: Soil, Plant, Water and Atmosphere Relationship

Soil and water as vital resources for agricultural production. Water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water. Soil irrigability classifications, factors affecting profile water storage. Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head. Field water budget water gains and water losses from soil, deep percolation beyond root zone, capillary rise. Evapotranspiration (ET) and irrigation requirement, critical stages of crop growth in relation to irrigation. Irrigation scheduling.

Plant water relations, concept of plant water potential, significance of osmotic adjustment, leaf diffusive resistance, canopy temperature, canopy temperature depression (CTD). Water movement through soil plant atmosphere system. Uptake and transport of water by roots. Development of crop water deficit, crop adaptation to water deficit, morpho physiological effect of water deficit. Drought tolerance, mechanisms of drought tolerance, potential drought tolerance traits and their measurements. Management strategies to improve crop productivity under limited water supplies. Contingent crop plans and other strategies for aberrant weather conditions. Cropping patterns, alternate land use and crop diversification in rain fed regions.

Unit 4: Hydrology and Soil and Water Conservation

Hydrologic cycle, precipitation, infiltration and surface runoff. Measurement and analysis of hydrologic data. Application of statistics in hydrology. Probability concepts. Distributions and application. Intensity duration frequency analysis. Hortonian and saturation overland flow theories, partial source area concept of surface runoff generation. Rainfall and run off relationships, stream gauging and runoff measurement. Different methods of surface runoff estimation, hydrographs, S-hydrograph, IUH, unit hydrograph theory and its application, Flood routing methods and calculations. Soil erosion and types of erosion. Soil loss measurement and

estimation. Universal soil loss equation and subsequent its modifications, soil and water conservation structures and their design. Gully control structures and their design. Design and construction of farm pond and reservoir. Seepage theory. Design of earthen dams and retaining walls, stability analysis of slopes. Mathematical models and simulation of hydrologic processes. Application of GIS in soil and water conservation.

Unit 5: Watershed Management

Watershed concept, Identification and characterization of watersheds. Hydrological and geomorphological characteristics of watersheds. Land capability and irritability classification and soil maps. Principles of watershed management. Development of watershed management plans, its feasibility and economic evaluation. Land levelling and grading, machineries and equipments for land levelling.

Unit 6: Irrigation Water Management

History of irrigation in India. Management of irrigation water. Major irrigation projects in India. Crop water requirements. Soil water depletion, plant indices and climatic parameters. Crop modelling, water production function. Methods of irrigation, surface methods, overhead methods, Pressurized irrigation system such as drip and sprinkler irrigation. Merits and demerits of various methods. Hydraulics of furrow, check basin and border irrigation, Hydraulics and design of pressurized irrigation systems. Irrigation efficiency and economics of different irrigation systems. Application and distribution efficiencies. Agronomic considerations in the design and operation of irrigation projects, characteristics of irrigation and farming systems affecting irrigation management. Irrigation legislation. Irrigation strategies under different situation of water availability, optimum crop plans and cropping patterns in canal command areas. Quality of irrigation water and irrigation with poor quality water. On farm water management, socio-economic aspects of on farm water management. Scope for economizing the use of water.

Unit 7: Management of Degraded, Waterlogged and Other Problematic Soils and Water

Problem soils and their distribution in India. Water quality criteria and use of brackish waters in agriculture. Excess salt and salt tolerant crops. Hydrological imbalances and their corrective measures. Concept of critical water table depths for crop growth. Contribution of shallow water table to crop water requirements. Management strategies for flood prone areas and crop calendar for flood affected areas. Crop production and alternate use of problematic soils and fish production.

Agricultural field drainage and theory of flow in saturated soil. Flow net theory and its application. Drainage investigations. Drainage characteristics of various type of soils. Water table contour maps and isobaths maps. Drainage coefficient. Design and installation of surface and subsurface drainage system. Interceptor and relief drains and their design. Drain pipe and accessories. Pumped drainage. Drainage requirements of crops. Drainage in relation to salinity and water table control. Reclamation of ravine, waterlogged, swampy areas and polders. Salt-affected soils and their reclamation. Command area development organizational structures and activities. River valley projects, interstate disputes. Water rights and legal aspects. Irrigation water users association concept and responsibilities. Environmental considerations in land and water resources management.

54. FOOD SCIENCE AND TECHNOLOGY

Unit 1 : Introductory Food Technology

Introduction to food technology. Food processing industries/institutions/food scientists of importance in India. Food attributes *viz*. colour, texture, flavour, nutritive value and consumer preferences. Causes of food spoilage, sources of microbial contamination of foods, food borne illnesses, water activity and its relation to spoilage of foods. Spoilage of processed products and their detection. Principles and methods of food preservation. Composition and related quality factors for processing. Methods of food preservation. Composition and related quality factors for processing. Methods of food preservation and heat processing, pasteurization, cannin, dehydration, freezing, fermentation, irradiation and chemical additives. Refrigerated and modified atmosphere storage. Aseptic preservation, hurdle technology, hydrostatic pressure technology, microwave processing etc.. Use of non-thermal technologies (microfilteration, bactofugation, ultra high voltage electric fields, irradiation, thermosonication), alternate-thermal technologies (ohmic heating, dielectric heating, infrared and induction heating) and biological technologies (antibacterial enzymes, proteins and peptides) in food processing.

Unit 2 : Technology of Foods of Plant Origin

(a) **Fruits and Vegetable Processing** Post harvest handling and storage of fresh fruits and vegetables. Preparation of fruits and vegetables for processing. Minimally processed products. Thermal processing and process time evaluation for canned products, process optimization, aseptic canning, methods for canning of different fruits, and vegetables; Dehydration and associated quality changes during drying and storage of dehydrated products. Solar drying. Intermediate moisture in foods. Preparation and utilization of fruits and vegetables juices in non-fermented/ fermented/ aerated beverages. Membrane technology. Chemistry and manufacture of pectin, role in gel formation and products like jellies and marmalades. Technology of preservatives, pickles, chutney's and sauces. Nature and control of spoilage in these products. By products utilization of fruits and vegetable processing industry. FPO and related formalities to obtain it. Processing methods of frozen fruits and vegetables, IQF products, packaging, storage and thawing. Tomato products such as juice, puree, paste, soup, sauce and ketchup. Other convenience foods from fruits and vegetables.

(b) **Foodgrain Processing -** Structure of different grains like wheat, rice, barley, oat, maize and millets etc. Milling of grains. Wheat flour/semolina and its use in traditional/non-traditional foods like breads, biscuits, cakes, doughnuts, buns, pasta goods, extruded, breakfast and snack foods. Preparation of vital wheat gluten and its utilization. Istant ready mixtures. Milling and parboiling of rice; by-products of rice milling and their utilization. Processed products from rice. Pearling, malting, brewing and preparation of malted milk feeds from barley. Milling of oats and its processing into flakes, porridge, oatmeal etc. Wet and dry milling of corn, manufacture of corn flakes, corn syrup, corn starch, corn steep liquor and germ oil.

Structure and composition of pulses and their importance in Indian diet. Milling and processing of pulses viz. germination, cooking, roasting, frying, canning and fermentation. Use in traditional products, protein concentrates and isolates. Oilseeds: edible oilseeds, composition and importance in India. Oilseed processing. Oil extraction and its processing. Production, packaging and storage of vanaspati, peanut butter, protein concentrates, isolates and their use in high protein foods. Export of oilseed cakes. International market and consumer preferences for quality in cakes for use in textured vegetable proteins.

Unit 3 : Technology of Foods of Animal Origin

(a) **Technology of Milk and Milk Products** Milk and Milk production in India. Importance of milk processing plants in the country. Handling and maintenance of dairy plant equipment. Dairy plant operations viz. receiving, separation, clarification, pasteurization, standardization, homogenization, sterilization, storage, transport and distribution of milk. Problems of milk supply in India. UHT, toned, humanized, fortified, reconstituted and flavored milks. Technology of fermented milks. Milk products processing viz. cream, butter, *ghee*, cheese, condensed milk, evaporated milk, whole and skimmed milk powder, ice-cream, butter oil, *khoa*, *channa, paneer* and similar products. Judging and grading of milk products. Cheese spreads by spray and roller drying techniques. Insanitization *viz*. selection and use of dairy cleaner and sanitizer. In plant cleaning system. Scope and functioning of milk supply schemes and various national and international organizations. Specifications and standards in milk processing industry. Dairy plant sanitation and waste disposal.

(b) **Technology of Meat / Fish / Poultry Products** Scope of meat, fish and poultry processing industry in India. Chemistry and microscopic structure of meat tissue. Antemortem inspection. Slaughter and dressing of various animals and poultry birds. Postmortem examination. Rigor mortis. Retails and wholesale cuts. Factors affecting meat quality. Curing, smoking, freezing, canning and dehydration of meat, poultry and their products. Sausage making. Microbial factors influencing keeping quality of meat. Processing and preservation of fish and its products. Handling, canning, smoking and freezing of fresh water fish and its products. Utilization of by-products. Zoovosic diseases. Structure and composition of egg and factors effecting quality. Quality measurement. Preservation of eggs using oil coating, refrigeration, thermostabilization and antibiotics. Packing, storage and transportation of eggs. Technology of egg products viz. egg powder, albumen, flakes and calcium tablets. Industrial and food user physiological conditions and quality of fish products.

Unit 4 : Food Quality Management
Objectives, importance and functions of quality control. Quality systems and tools used for quality assurance including control charts, acceptance and auditing inspections, critical control points, reliability, safety, recall and liability. The principles and practices of food plant sanitation. Food and hygiene regulations. Environment and waster management. Total quality management, good management practices, HACCP and codex in food. International and National food laws. US-FDA/ISO-9000 etc. Food adulteration, food safety. Sensory evaluation, panel screening, selection methods. Sensory and instrumental analysis quality control. Quality control of food at all stages and for packaging materials.

Unit 5 : Food Engineering/Packaging and Labeling
Unit operations of food processing, machineries for various unit operations, energy balance in food processing. Packaging materials *viz.*properties and testing procedures, packaging of fresh and processed foods. Shelf life studies. Recent trends in packaging aseptic, modified atmosphere, vacuum and gas packaging etc. Nutritional labeling requirements of foods. Requirements and functions of containers. Principles of package design.

Unit 6 : Food Biotechnology
Role of biotechnology in productivity of plants, livestock and microbes of improved nutrition and quality. Use of biotechnology in production of food additives. Use of biotechnologically improved enzymes in food processing industry, biomass production using industrial wastes. Consumer concerns about risks and values, Biotechnology and food safety. Future of biotechnology in India.

Unit 7: Flavor Chemistry Technology:
Flavor composition of foods/beverages (identification and quantitative analysis of the flavor precursors and their products, characterization of the staling reaction using stable isotopes). Flavor composition of foods/beverages in relation with maturation and microbial activity/or the processing conditions (e.g. fermented dairy products, beer, wine, honey, fruits) etc. Analysis of odour-active compounds of food/beverages (Charm analysis). Synthesis of flavour by microorganisms and plant cells. Lipid derived flavors. Investigation of equilibrium of key flavour compounds that govern the flavor stability of beverages. Natural antioxidant constraints in spices.

Unit 8: Consumer Sciences / Food Product Development / Health Foods
Sociocultural, psychological and economical consideration for food appearance, domestic and export marketing. Consumer trends and their impact on new product development. Product development *viz.* to conceive ideas, evaluation of ideas, developing ideas into products, test marketing and commercialization. Role of food in human nutrition. Nutritional disorders associated with foods. Diet therapy. Therapeutic / Engineered / Fabricated and Organic foods.

55. DAIRY CHEMISTRY

Unit 1

Milk constituents, their normal contents and physical and chemical nature. Specific compositional differences among milk from various species; Variations in milk composition due to breed, feed, season, stage of lactation and mastitis; Colostrum and abnormal milks, physical properties of milk; Acid base equilibria, oxidation-reduction potential, density, viscosity, interfacial tension, freezing point, electrical conductivity, thermal conductivity, refractive index, milk buffer capacity, physical equilibria among milk salts; Effect of various treatments on salt equilibria; Salt balance and its importance in processing of milk; Water activity, and its effect on shelf life; Colloids, properties and colloidal stability of milk; Emulsions, foams and gels formation, their stability and importance in dairy processing.

Lactose – structure, isomers, physical, chemical and biochemical properties. Browning mechanisms. Estimation and biosynthesis. Lactose intolerance. Significance of carbohydrates in milk and milk products. Distribution of trace elements in milk and their technological and nutritional importance; Water soluble vitamins – molecular structure and their levels in milk and milk products, biological significance, and factors affecting their levels.

Unit 2

Levels, distribution, isolation and genetic polymorphism of different milk proteins; Casein micelles – structure, size distribution, stability and physico-chemical properties; Casein models. Amino acid composition and physico-chemical properties of different fractions of caseins; Whey process, denaturation of milk proteins as influenced by temperature, pH and additives; Biosynthesis, structure, function and physico-chemical properties of α-lactalbumin and ß-lactoglobulin, immunoglobulins, lysozyme, lactoferrins, lipoproteins and fat-globule membrane proteins and their importance; Milk protein allergenicity; Role in immune response; Chemistry of milk enzymes and their significance with reference to milk processing and milk products. Kinetics of chemical reactions and enzyme kinetics; Casein hydrolysate, co-precipitates, and whey protein concentrates; bioactive peptides.

Unit 3

Milk lipids – classification, composition, structure and general physical and chemical properties. Auto-oxidation – definition, theories, factors affecting, prevention and measurement. Antioxidants – mechanism of reaction and estimation. Lipolysis. Fatty acids – profile, properties and affecting factors. Unsaponifiable matter. Cholesterol – structure, forms, importance and level in milk. Chemistry of phospholipids and their role in milk and milk products. Fat – soluble vitamins – chemistry, physiological functions, levels in milk, cream, butter and ghee. Biosynthesis of milk fat. CLA biosynthesis and its nutritional and health benefits.

Unit 4

Milk adulteration and detection methods; Estimation methods for antibiotics, pesticides, heavy metals, lactose, lactate, protein, total solid, fat, salt, vitamin C, calcium, phosphorous, iron, citric acid in milk and milk products. Estimation of vitamin A, total phospholipids and free fatty acids in ghee. Estimation of starch in food. Measurement of BOD and COD in dairy waste.

Unit 5

Cream – Size distribution of fat globules, creaming phenomenon, composition and properties of cream and dry cream. Chemistry of neutralization and ripening. Butter. Mechanism of churning during butter preparation. Desi and creamery butter composition, properties, microstructure, grading, standards and defects. Ghee – Compositional differences in ghee prepared by different methods and variations in ghee and butter oil, Analytical constants and factors affecting them. Differences in cow and buffalo ghee. Hydrolytic and oxidative deterioration of ghee, their causes and prevention. Adulteration of ghee and methods of detection. Ghee grading, Antioxidants: natural and synthetic. Physico-chemical characteristics of buttermilk and ghee residue.

Unit 6

Heat stability of milk as affected by various milk constituents and additives. Role of protein-protein interaction and age gelation of UHT milk. Physical and chemical changes during preparation of concentrated milk and subsequent storage. Compositional differences between condensed and evaporated milk. Dried milk; Structure and physico-chemical properties. Physical properties of instat powder, Infant food. Spoilage of milk powder and its control. Khoa : composition and changes during manufacture. Composition and changes during preparation of chhana and paneer.

Unit 7

Cheese : Composition and varietal differences. Chemistry of rennin action. Influence of acidity, renneting and heat on the process of cheese manufacture. Changes during manufacture and ripening. Role and mechanism of action of stabilizers and emulsifiers, rheological properties and defects of cheese. Milk clotting enzymes from different sources – microbial, animal and plant. Theories and metabolic pathways of fermentation. Dahi, yoghurt and Acidophilus Milk : Composition and specific differences, chemical changes during fermentation, flavour development. Composition of Lassi and buttermilk. Nutritional and therapeutic significance of fermented milk products.

Unit 8

Ice-cream : Composition and physical structure, changes during ageing, freezing, hardening and defects. Role and mechanism of stabilizers and emulsifiers. Kulfi: composition and differences with ice-cream.

Unit 9

Definition of quality, quality control and assurance. Standards, statutory and voluntary organization. PFA act, sampling, labelling, PFA and AGMARK, BIS, ISO9000 standards for milk products. Total quality management, sensory evaluation of milk and milk products. Calibration of glasswares (lactometer, butyrometer, milk pipette, thermometer) used in Quality control laboratory, legal requirements of packaging material and product information, nutrition labelling.

Unit 10

Spectroscopy – UV – Vis spectrophotometry, IR. Separation techniques : TLC, GLC, HPLC, Ion exchange, size exclusion, affinity chromatography, analytical sedimentation, sedimentation equilibrium, isopycnic ultracentrifugation. Ultrafiltration. Precipitation by salting out agents. Electrophoresis – PAGE, SDS-PAGE, Radio-tracers technique. Flame photometry and potentiometry (principle, various electrodes, electrometric measurements of pH, buffers).

56. DAIRY MICROBIOLOGY

Unit 1

Microflora associated with milk and milk products and their importance. Morphological, natural, physiological, spoilage and pathogenic characteristics of commonly occurring microbes in milk and milk products; Newer approaches for classification of microorganisms; types of microbes in normal and mastitic milk and importance of somatic cell counts; Food poisoning, food infections, toxi-infections and other milk borne diseases; Emerging food borne pathogens associated with milk and milk products; Epidemiological studies using DNA fingerprinting techniques like RAPD, RFLP, DGGE, TGGE, Rep-PCR, etc. Sources of microbial contamination of raw milk and their relative importance in influencing quality of milk during production, collection, transportation and storage. Microbial and chemical changes in raw milk during chilling and refrigeration.

Unit 2

Bacteriological aspects of processing techniques like bactofugation, thermisation, pasteurization, sterilization, boiling. UHT, pulsed field treatment and membrane filtration of milk. Types of spoilages in heat-treated milks. Enumeration of heat resistant microbes. Germination and sporulation of bacterial spores; Prevention of post-processing contamination in heated milk. Identification of sources of contamination in heat treated milks. D, F and Z values for various microbes. Heat induced damage and repair in bacterial cells. Role of resuscitation in recovery of heat injured microbial cells; Bacteriological grading of raw and heat-treated milk. Microbiological spoilage aspects of thermally processed milks; Role of psychrotrophic, thermoduric, thermophilic bacteria and their metabolites in milk spoilage, biofilms.

Unit 3

Naturally occurring preservative systems in milk like LP system, Immunoglobulins, Lysozyme, Lactoferrin, etc. Preservation of milk and milk products by physical (irradiation) and chemical agents; Food grade Biopreservatives (GRAS), Bacteriocins of lactic acid bacteria; Nisin and other antimicrobials produced by Lactic Acid Bacteria (LAB). Application of bacteriocins as food grade biopreservatives in enhancing shelf life of foods; Enhancing antimicrobial potentials of LAB by recombinant DNA technology and Genetic engineering; Residues of antibiotics, detergents, sanitizers, pesticides and aflatoxins in milk, mode of action on microbes and biological consequences – as well as their detection by newer approaches like Charm test, HPLC, ELISA and biosensor based techniques.

Unit 4

Microbiological quality of fat rich products (cream and butter); Frozen dairy products (ice-cream); Concentrated dairy products (evaporated and sweetened condensed milk) and Dried milks (roller and spray dried milks and infant foods); Factors influencing the microbiological quality of above products during their production, processing, handling, storage and distribution; Microbial defects associated with these products and their control; Microbiological safety in relation to potential pathogens and their public health significance; National and International microbiological standards for dairy products (BIS, ICMSF, Codex Alimentarius Standards).

Unit 5

Lactic Acid Bacteria (LAB) as starters : Types of starter cultures and their classification; Identification of LAB based on conventional and molecular techniques such as 16S rRNA sequencing. Ribotyping, PCR and DNA fingerprinting; Microbiology of starter cultures; Single and multiple strain cultures, and custom cultures; Associative growth of starter cultures; Concepts of starter growth and metabolism of lactose and citrate; Production of taste and aroma compounds by starters in fermented milks and milk products; Changes caused by starters in milk during growth; Modem trends in propagation, production and preservation of starter cultures; Production of starter concentrates; DVS starters: Judging of starter quality and activity; Starter defects; Starter failure; Intrinsic and extrinsic factors associated with starter failure; Bacteriophages of dairy starters and their impact on dairy industry; Prevention and control of starter failures.

Genetics and molecular biology of acid, flavour and therapeutic properties of LAB. Role of plasmids in their metabolism; Genetic manipulation of LAB for ameliorated performance; Food grade cloning and expression vectors; LAB as hosts for expression for heterologous proteins and development of food grade oral vaccines; LAB genome projects.

Unit 6

Dairy products as functional / health foods : LAB as probiotics in development of health foods; Selection criteria, colonization and functional properties; Antibacterial and therapeutic properties of probiotic cultures; Survival and stability of probiotics in health foods, gut and their tracking; Concept of probiotics and synbiotics; Genetic markers of probiotic functions and their application for mass screening; Genomics of probiotic Lactobacilli and Bifidobacteria; Cloning and sequencing of probiotic genes; Sequence analysis; Blast, Clustal W and Clustal X. Pair-wise and multiple alignment; Homology and Phylogenetic tree / dendrograms; LAB as nutraceutical ingredients – a source of vitamin synthesis and exopolvsaccharide production; Bioactive peptides and their role as nutraceuticals in dairy foods.

Unit 7

Role of starters in the preparation of yoghurt, koumiss, kefir, cultured buttermilk, and whey based beverages and other fermented products; Therapeutic properties of fermented foods; Microbial defects in these products, safety and their prevention and control; Microbiology of hard, semi-hard and soft varieties of cheese; Role of starter culture and non-starter lactic acid bacteria (NSLAB) during preparation and ripening of cheese; Accelerated ripening of cheese; Production and use of microbial rennet substitutes; Recombinant chymosin and its application; Defects in cheese, Microbiological safety and their prevention and control.

Unit 8

Microbiological quality of indigenous dairy products, viz., khoa and chhana based sweets: Burfi, peda, rasogulla, gulabjamun, kheer, kulfi, shrikhand, paneer, dahi, lassi, ghee, etc. Sources of microbial contamination, their role in spoilage of these products and their microbiological safety, Prevention and control: Role of personnel and environmental hygiene at the level of production and processing; Need for microbiological standards for assessing the quality and safety of indigenous products; Concept of TQM and HACCP implementation in improvement of quality

and safety of indigenous products; Current role of modified packaging for extending the shelf stability of indigenous dairy products, Antimicrobial packaging, controlled and modified atmosphere (CAP / MAP) based technologies.

Unit 9

Preparation of byproducts from dairy effluents by microbial fermentation; Cleaning and sanitization of equipments, machineries and other contact surfaces used in production and processing of milk and milk products; Types of detergents and their mechanisms of soil removal from the surfaces; Efficacy of sanitizers including gaseous disinfectants and evaluation of sanitizing disinfectant properties; Factors affecting activity of detergents and sanitizers; Built detergents, commercial detergents and combined detergent-sanitizers; Biological consequences of dairy waste disposal; Disposal of dairy effluents after microbial treatment; BOD and COD analysis in dairy effluents; Microbiological quality of air and water used in Dairy Plants.

Unit 10

Microbiological aspects of quality control and quality assurance in production of milk and milk products; Good Manufacturing Practices (GMP) and the relevance and Sanitary Standard Operating Procedures (SSOP); Importance of Total Quality Management (TQM) in dairy industry; Application of HACCP programme in dairy industry; Safety concerns of bio-film formation on equipment surfaces and their control measures; Risk assessment approaches and role of productive microbiology in dairy foods; Conventional and current methods like imepdence, ATP luminescence, pyruvate, etc. in detection of food pathogens; Application of immunological, PCR, Real time PCR, DNA probes, Microarrays (Biochips) and Biosensors, etc. for detection of food pathogens; Biosafety of Genetically Modified Organisms (GMOs) / foods.

57. DAIRY TECHNOLOGY

Unit 1 : Market Milk

Status of dairy industry in India. Recent policy changes related to dairy sector (MMPO & WTO). Principles and practices for production of high quality milk. Methods of milk procurement, payment, quality assessment, detection of adulterants, handling and transportation of milk. Methods of raw milk preservation. Physical properties and chemical composition of milk of cow, buffalo and other species of milch animals; their importance in milk processing. Centrifugal separation, clarification and bactofugation and factors affecting their efficiency. Homogenization process and its implications in dairy processing; efficiency of homogenization and factors affecting it. Thermal processing of milk. Principles and methods of pasteurization and sterilization. UHT processing and aseptic packaging. Special milks. Principles of production, processing and marketing of toned, double toned, reconstituted, recombined, flavoured and filled milks.

Unit 2 : Fat Rich Dairy Products

Basic principles and recent concepts in production and processing of different types of cream, butter, margarine, fat spreads, butter oil and *ghee*. Fractionation of fat and its application. Health aspects of milk fat. Cholesterol reduced and cholesterol-free dairy products.

Unit 3 : Frozen Milk Products

Trends in the frozen milk products industry in India. Definition, classification and composition of ice-cream and other frozen desserts. Role of milk constituents and other ingredients, processing steps, packaging and storage methods on quality of ice-cream. Technological aspects of manufacture of plain, fruit, soft-serve, low fat and dietic ice-creams and novelties. Indigenous frozen desserts, kulfi, malai-ka-baraf etc.; their production techniques and quality. Distribution of frozen desserts. Newer ingredients for use in the ice-cream industry.

Unit 4 : Cheese and Fermented Milk Products

Status and scope of cheese industry. Fermented milk products – their nutritional and therapeutic value. Definition and classification of cheese and fermented milks. Milk in relation to cheese making. Manufacture of Cheddar, Gouda, Mozzarella and Swiss cheeses. Role of starter cultures in cheese quality. Types of rennet for cheese manufacture. Physical and chemical changes during cheese ripening. Manufacture of processed cheese, cheese spread and cheese foods. Mechanization of cheese-making process. Modern concepts in accelerated cheese ripening. Storage and defects. Production and storage of *dahi,* yoghurt, *shrikhand, lassi* and *misti dohi*. Probiotic dairy products.

Unit 5 : Concentrated and Dried Milk Products

Milk in relation to processing and manufacture of concentrated and dry milks. Principles and methods of manufacture, storage and defects in sweetened condensed milk. Evaporated milk. UHT sterilized concentrated milk. Whole milk powder. Skim milk powder, high-fat powders, and ice-cream powder. Instantization of milk powder. Newer technologies and formulations for infant foods and weaning foods, malted milk and malted milk foods.

Unit 6 : Indigenous Milk Products
Status and role of traditional dairy products in Indian dairy industry and economy. Characteristics of various traditional products, their prospects and constraints. Methods of production; physico-chemical changes during manufacture; quality attributes, shelf-life, preservation and packaging. Process innovations relating to *khoa, chhana, paneer, rabri, kheer, khoa* and *chhana*-based sweets.

Unit 7 : Utilization of Milk Byproducts
Status, availability and utilization of dairy byproducts. Associated economic and pollution problems. Manufacture of casein, sodium and calcium-caseinates, edible casein, hydrolysates, coprecipitates, whey protein concentrates, whey beverages, whey syrups and lactose. Use of buttermilk. Development / formulation of new products based on dairy byproducts.

Unit 8 : Packaging of Milk and Milk Products
Present status and scope. Role of packaging and package design considerations. Evaluation of packaging materials and package performance. Packaging materials and systems for liquid, concentrated, dried, frozen and fat-rich dairy products. Special packaging methods such as vacuum, shrink and aseptic packaging. Modified atmosphere packaging. Package standards, regulations and quality control.

Unit 9 : Cleaning and Sanitation
Properties of important dairy detergents and sanitizers. Choice of detergents and sanitizers guiding principles and limiting factors. Basic principles in formulating the cleaning and sanitizing procedures for dairy equipments. Automation in cleaning and sanitization processes including CIP. Quality of water in detergency.

Unit 10 : Advances in Dairy Technology
Radiation preservation of milk and milk products. Theory and application of microwave heating, ohmic heating and high pressure processing. Immobilization of enzymes and their use in dairy and food industry. Theory of ultrafiltration, reverse osmosis, nanofiltration and microfiltration techniques. Selection and types of membranes. Application of membrane technology in dairy and food industry. Fouling, cleaning and sanitization of membranes. Emulsions, foams and gels. Electrodialysis and ion exchange in dairy applications. Processing of cereals and legumes for incorporation in milk and milk products. Use of milk solids in bakery and confectionery products. Application of biotechnology in dairy industry.

Unit 11 : Legal and Quality Aspects for Milk and Milk Products
Safety aspects of milk with reference to mycotoxins, antibiotics, pesticides, weedicides and heavy metals. PFA, BIS and Agmark standards for milk and milk products. Quality systems such as HACCP, ISO certification, etc.

58. DAIRY ENGINEERING

Unit 1 : Heat Transfer
Fourier's law, Steady state heat conduction through slab, pipe wall and fin. Emperical relations for convective heat transfer for flow through pipe and parallel plates. Consideration and boiling heat transfer. Shape factor and radiation heat transfer. Unsteady state heat conduction in simple geometry. Analytical and numerical solutions to transient state heat transfer. Common heat exchangers used in dairy plants and their effectiveness.

Unit 2 : Transport Phenomenon
Mass transfer and molecular diffusion in solids, liquids and gases. Fick's law. Estimation of mass transfer coefficient. Mass balance in equilibrium stage operators. Momentum transfer. Equation of continuity. Equation of motion. Pipe flow. Friction factor and flow rate relationship. Drag on spherical particles. Flow through porous media. Characteristics of Newtonian and non-Newtonian fluids. Momentum, heat and mass transfer analogies.

Unit 3 : Engineering Properties of Food Materials
Concept of Rheology, ideal, elastic, plastic and viscous behaviour. Viscoelastic models. Stress strain behaviour, creep and stress relaxation. Application of aerodynamic properties for pneumatic handling and conveyance of food products. Water activity of foods, water sorption isotherm and water activity measurement methods. Permeability and shelf-life prediction of dairy products.

Unit 4 : Mechanical and Thermal Operations in Dairy Processing
Centrifugal separation of solid, liquid and gas mixtures. Cyclone, cream separator and clarifiers. Construction and operation of butter and cheese making equipments. Size reduction of particulate solids. Homogenization, sedimentation and settling. Filtration, agitation and mixing, Crystallization. Flexible packaging and aseptic packaging. Pasteurization, Sterilization and UHT processing of milk. Process time calculations based on heat resistance of microorganisms and quality attributes of milk. Freezing of food, ice-cream freezers, freeze concentration and freeze drying.

Unit 5 : Evaporation and Drying of Foods
Material and energy balance. Design of single and multiple-effect evaporators. Design of thermo-compression system. Design of spray dryer and its components. Design of drum dryer. dairy plant and process plant piping systems. Dehumidification operations.

Unit 6 : Instrumentation and Control Engineering
Mechanical, electrical, magnetic, optical and other types of transducers. Instruments for measurement of pressure, temperature, radiation, humidity, vacuum, fluid flow and liquid level. Principles of automatic process control and control elements. Proportional, integral and derivative controllers. Data acquisition, retrieval and processing

Unit 7 : Plant Utilities and Sanitation

Steam generation and their properties. Boiler and their accessories. Steam load diagram. First and Second law of thermodynamics. Vapour compression refrigeration system, elements and controls, defrosting, condensers. Cold storage designs and cooling load calculations. Ion exchangers in water softening and demineralization operations in dairy plants. Waste water treatment and pollution control laws. Hygiene and sanitization, CIP cleaning. Dairy plant layout and design.

Unit 8 : Design of Process Equipments

Design of pressure vessels under varying pressure and temperature. Corrosion mechanism and control. Design of cylindrical and spherical shells. Fabrication requirements. Design of heat exchangers, shell and tube heat exchangers, construction codes and general design considerations. Design of reactor vessel.

59. MECHANICAL ENGINEERING

Unit 1 : Thermodynamics
Laws of thermodynamics. Availability and irreversibility. Entropy, T-S and H-S diagrams for gases and vapours. Otto, Diesel, Duel, Sterling and Bryton cycles and their efficiencies. Themodynamics of non-reacting mixtures. Single stage and multistage air compressors with intercooling. Rotary units.

Unit 2 : Power Plant Engineering
Prosperties of steam. Ranking cycle. High pressure and high duty boilers. Fire and water tube boilers. Steam nozzles, critical pressures and nozzle efficiency. Steam turbines, impulse and reaction types. Draft and dust removal equipments. Condensers. Economisers. Heat balance. Economics of power generation. Selection of site for steam, hydro and nuclear power plants.

Unit 3 : I.C. Engines and Automobile and Engineering
Types of I.C. Engines. Ignition, injection and carburetion methods. Preignition and detonation. Modern fuel injection system. Calorific values of fuels. Octane and cetane ratings. Governing, cooling, lubrication, transmission and electrical systems. Fluid drive. Supercharging and scavenging methods. Duel fuel engines including use of biogas, LPG and CNG. Engine exhust and pollution control. Chassis. Steering mechanism, braking system and wheel alignment.

Unit 4 : Refrigeration and Airconditioning
Vapoar compression and absorption system of refrigeration. Coefficient of performance. Effect of design and operating parameters on performance. Refrigerants and their selection. Multiple evaporators and multistage compressor system. Condenser, evaporator and expansion devices. Refrigerated vans and design of cold storage. Air-conditioning and psychometric properties. Comfort criteria. Heating and cooling load calculation.

Unit 5 : Heat Transfer
Conduction convection and radiation. Steady and unsteady heat conduction through cylindrical and plane surfaces. Free and forced convection. Heat transfer from fins. Condensation and boiling heat transfer. Nusselt's correlations. Concept of black and grey surfaces. Parallel and counter flow heat exchangers. Design and performance of heat exchanger.

Unit 6 : Fluid Mechanics and Fluid Machinery
Bernoulli's theorem for flow through pipes, various losses, orifices, venturimenter, pitot tubes and manometers. Boundry layer. Continuity equation,. Velocity and stream function. Source and sink. Vorticity. Navier Strokes equation of motion. Impact of jets, impulse and reaction turbines and their governing. Reciprocating, rotary and centrifugal pumps. Fluid systems, Hydraulic ram, jet pump and hydraulic accumulator.

Unit 7 : Theory of Machines and Vibration
Kinematic and dynamic analysis of plane mechanisms. Lower and higher pairs. Belts, ropes and chains. Gear tooth profiles and kinematics of gears, gear trains. Governors and flywheels. cams.

Balancing of rotating and reciprocating masses. Free and forced vibration of single and two degree of freedom systems with or without damping. Critical speed and whirling of shafts.

Unit 8 : Mechanics of Solids

Simple stresses and strains. Principal stresses and strains. Mohr's construction. Elastic constants. Uniaxial loading. Thermal stresses. Simple bending of beams. Shear force and bending moment. Slope and deflection of beams. Shear stresses in beams. Thick and thin pressure vessels. Curved beams. Torsion of shafts. Close and open coiled helical springs. Struts and columns. Strain energy concepts and theories of failure. Rotating discs. Shrink fit.

Unit 9 : Machine Design

Design of riveted and welded joints. Knuckle and cotter joints. Screw and screw jack. Belts, ropes, chains and gears. Hydrodynamic lubrication and journal bearings. Antifriction bearings. Leaf and helical springs. Brakes, clutches, couplings, shafts and keys. IC engine parts.

Unit 10 : Manufacturing Engineering

Working of lathe, drill, shaper, milling machines, presses and welding sets. Basic concepts of CAD/CAM, NC, CNC, FMS, ECM, EDM and ultrasonics. Moulding of ferrous and nonferrous materials. Forming processes. Heat treatment. FRP and its uses. Jigs and fixtures, tools and gauges. Inspections of length, position, profile, surface finish, screw threads and alignments. Merchant's force analysis. Taylor's tool life equation. Machinability and machining economics.

Unit 11 : Manufacturing Management

Production planning and control. Forecasting, moving average. Operations scheduling, assembly line balancing. Product development. Break even analysis. Capacity planning. PERT and CPM. Inventory control, ABC analysis, EOQ model. Job standards. Work measurement. Quality control. Operations research, linear programming, graphical and Simplex methods. Transportation and assignement model. Simple quing models. Value engineering. Total quality management. Forecasting techniques. Project management.

60. ELECTRICAL ENGINEERING

Unit 1 : Basic Circuit Analysis
Kirchoff's laws. Combination of circuit elements (R.L>M>andC.). Network theorems: superposition. Thevenin and Norton. Maximum power transfer. Star-delta transformation. Mesh and nodal analysis. D.C. transients in RL. RC and RLC circuits. AC circuits definitions pertaining to a.c.quantities, phasor representation of sinusoids, analysis of RLC circuits. Resonance. Three phase circuits. Power factor and power calculations. Laplace transform and its use in circuit analysis. Magnetic circuits, Faurier series.

Unit 2 : Control Systems
Concept of feedback control systems. Time domain and frequency domain analysis of first and second order control systems. Stability. Routh-Hurwitz crieterion. Mathematical models of physical systems. Derivative and integral control.

Unit 3 : Transformers
Theory, operation and performance of single phase and three phase transformers. Short circuit and no-load tests. Parallel operations of transformers. Auto transformer. Transformer connections.

Unit 4 : D.C. Machines
Types of generators and motors and their performance characteristics. Starting of DC motors and their speed control including solid state devices.

Unit 5 : A.C. Machines
Single-phase motors. Star-delta and DOL starters. Electronic speed control of motors. Three phase AC machines, generators and motors. Induction generator.

Unit 6 : Power Generation, Transmission & Distribution
Different types of power generation. Transmission lines. Distibution lines and calculation of power losses. Voltage regulation. Protection switchgear: fuses, relays, lightning arrestors and circuit breakers. Computer applications.

Unit 7 : Basic Electronics
Semi-conductors: p-n junctions. Diodes and transistors. Rectifiers and filter circuits. Low frequency voltage and power amplifiers. Operational amplifier RC oscillators. SCR's and photo diodes. Multi-vibrators. Integrated circuits.

Unit 8 : Measuring Instruments
Transducers: displacement, velocity, acceleration, pressure, temperature, strain, basic D'Arsonval's movement, Voltmeter, ammeter, wattmeter and energy meters. DC and AC bridges. Measurement errors, Digital instruments, C.R.O.

Unit 9 : Digital Electronics
Digital circuits. Logic gates and flip-flops. Boolean algebra. Simplification of Boolean functions. Binary arithmetic. Half and full adders and counters. Elements of digital computer. Asynchronous circuits.

Unit 10 : Electromagenatics
Coulomb's law, Electric field intensity, Gauss's Law, Electric potential, current and current density, conductors and insulators, capacitance and dielectric materials.

Unit 11 : Microprocessors
Organisation of microcomputer; programming of micro-processors – register set, addressing modes, instruction set and programming techniques; microprocessor as the CPU; timing details, memory and I/Q interfacing techniques; peripheral interfacing devices.

61. ELECTRONICS AND INSTRUMENTATION

Unit 1 : Semiconductor Devices
PN diode, PIN diode, Zener, Varactor, shotkey and Tunnel diode, LED.
BJI, JFET, MOSFET, THYRISTOR, UJT
Operation characteristics and equivalent circuit.
Biasing of BJT and JFET.
Operating point and its stability.

Unit 2 : Diode Applications
Reatifier and filters, wave shaping and clamping.
Zener diode as voltage regulator
Introduction to regulated power supply.

Unit 3 : Amplifiers and Oscillators
Small signal analysis of BJT, JFET amplifiers, cascading and cascading, Frequency response of RC coupled amplifiers.

Introduction to tuned amplifier.
Feed back (series and shunt), Voltage and current feedback.

Oscillators, Operational amplifier and its application in analog computation, DIFF-AMP using three op-amps frequency response and compensation.

Classification of amplifers, power amplifers, push-pull amplifiers.

Unit 4 : Digital Electronics
Transistor as switch.
Logic gates, Arithmatic binary adders and subtractors, Enoder and Decoder, Controlled inverter, 1'S, 2'S, 9'S Complement generator.
Karnaugh map
Flip flops, register and counter.
A/D and D/A converter
Introduction to Microprocessor.

Unit 5 : Radio Electronics
Modulation and demodulation circuits for AM, FM, PM Transmission and reception of radio signal.
Elementary antenna and propagation.
Introduction to satellite and optical communication.

Unit 6 : Basic Measurements and Laboratory Instruments
Basic electrical standars, errors in measurements.
Measurements of current, voltage and power.
Electronic voltmeter and multimeter
Thermoelectronic voltmeter for true RMS measurement.
AC and DC potentiometers, Bridges, CRO, XY recorder.

Digital instruments for measuring current, voltage, time, resistance and frequency.

Unit 7 : Measurement of Non-electrical Quantity
Transducers, instrumentation amplifier.

Signal conditioning, measurement of displacement, force, torque, pressure, strain, velocity temperature.

Data acquisition and introduction to telemetry.
Fiber optic sensors single mode and multimode type.
Measurement of humidity absorption.

Unit 8 : Automatic Controls
Feedback principles in control systems
Servo systems
Self balancing potentiometers
Various controller and their characteristics
PLC in process control.

62. TEXTILE CHEMISTRY

Unit 1 : Basic of Textile Science
Classification of textile fibres according to their source and chemical composition. Occurrence, morphology, constitution, physical and chemical properties and uses of cellulosic fibres like cotton and jute and protein fibres like wool and silk.

Unit 2 : Basics of Polymer Science
Raw materials, manufacturing processes, physical and chemical properties and uses of regenerated cellulosic fibres like viscose rayon, cuprammonium rayon and cellulose acetate. Manufacture, physical and chemical properties and uses of polynosic, tencel and other modified viscose rayon fibres.

Unit 3 : Polymer Chemistry
Fundamentals of polymer chemistry. Chemistry of addition and condensation polymerization. Fine structure of fibres. Crystallinity and orientation of fibres and their determination. Methods to investigate fibre structure. Fibre forming characteristics of polymer. Fibre structure in relation to spinning and drawing of manmade fibres. Determination of molecular weight of fibres. Swelling and solubilisation of fibres. Relation between fibre structure and physical properties.

Unit 4 : Polymer and Fibre Usage
Raw materials, manufacturing processes, physical and chemical properties and uses of important synthetic fibres like polyester, nylon 66,. Acrylic, polypropylene and polyurethane. Fibre modification. Fibre waste and its utilization. Manufacture, properties and uses of speciality fibres like glass, carbon and aramid fibres.

Unit 5 : Natural and Synthetic Fibres
Sizing of textile yarns. Preparatory processes for textile materials. Removal of natural and added impurities from vegetable and animal fibres. Designing, scouring and breaching of cotton. Machines used for scouring and bleaching of cotton. Impurities in wool and silk and processes for their removal. Use of enzymes in preparatory processes. Scouring, bleaching and optical whitening of manmade and blended textiles. Surface activity and detergency. Combines preparatory processes and energy conservation. Heat setting of synthetic textiles. Effulent treatment and pollution control. Recent advances in preparatory processes.

Unit 6 : Textile Finishing Technology
Classification of textile finishes. Finishing agents. Machines used for different mechanical finishes. Drying of textiles. Anti-shrink finishes. Physical and chemical aspects of mercerization of cotton and its blends. Determination of mercerization efficiency and factors affecting it. Machines used for mercerization. Other finishes based on swelling of cotton. Finishes for improving wrinkle resistance, was and wear, and durable press properties of fabrics. Formaldehyde-free finishes. Soil release finishes. Finishes for improving resistance of textile

fabrics to fire, micro-organisms and weathering. Water-proofing and water-repellent finishes. Anti-felting and other finishes for wool. Finishes for synthetic and blended fibre fabrics. Finishing of knitted garments. Energy requirement and conservation in finishing. Recent advances in finishing processes.

Unit 7 : Dyeing Science

Natural dyes. Classification of synthetic dyes according to their chemical constitution and application. General considerations of the application of different classes of dyes to textile fibres and their blends. Machinery and processes used for dyeing. Mass colouration of man-made fibres Garments dyeing. Fastness properties of dyed materials. Economics of dyeing processes. Colour theory and Computerized colour matching applications. Physical chemistry of dyeing important textiles fibres. Factors affecting equilibrium absorption and kinetics of dyeing, and nature of absorption isotherms. Affenity of dyes, heat of dyeing, entropy changes during and nature of dye-fibre bonds. Effluent treatment and pollution control. Recent advances in dyeing processes.

Unit 8 : Printing of Textiles

Print paste formulation. Natural and synthetic thickeners. Different methods and machinery for printing natural, synthetic and blended fibre fabrics. Styles of printing. Roller, flat bed and rotary screen printing machines. Transfer printing of polyester fabrics. Novelty printing effects. Economics of printing process. Recent developments in printing technology such as computer aided print designs, ink jet printing etc..

63. TEXTILE MANUFACTURE

Unit 1 : Introduction to Textile Manufacture Sciences
Different methods and principles of developing basic patterns *viz.* drafting, flat pattern method and draping. Grading of patterns. Study of traditional textiles and costumes of India and their influence on contemporary trends in fashion. Apparel designing apparels. Structural and applied designs in apparels. Figure irregularities and special problems with reference to apparel designing. Sewing techniques and their applications in manufacturing of apparels/garments. Apparel standards, specification and costing.

Unit 2 : Processing of Textiles and Yarns
Precessing / manufacturing of different textile fibres like cotton, silk, wool, mineral fibre, rayon and synthetics – their physical, chemical and biological properties. Blending and its principles, types and technology. Quantitative estimation of blends and mixtures in textiles. Classifications, characteristics and use of different yarns. Methods of basic construction-woven and non-woven. Textiles finishes-mechanical, additive, chemical and special finishes. Water, detergents, optical brightners-types and their effect on fabric performance.

Unit 3 : Dyes and Pigments
Study of dyes and pigments. Natural (ecofriendly dyes) and synthetic (chemical) dyes. Advantages and disadvantages. Classifications, compositions, propertieas and applications of synthetic dyes. Natural dyes-sources and applications on dyeing of textiles. Colourfastness tests. Advanced dyeing and printing and printing methods.

Unit 4 : Textile Standards and Quality Testing
Importance of textile testing – standardization and quality control. Standard conditions for textile. Textile testing standards and methods. Fibre testing: Length, strength, microscopy, fineness etc. Yarn testing: Strength and elongation, twist, count, crimp, evenness etc.. Fabric testing: Fabric count, balance, weight, thickness, strength (breaking,. Tearing, bursting), elongation, abrasion resistance, pilling, crease recovery, stiffness, air permeability, drapability, water permeability etc..

Unit 5 : Textile Designs
Analysis of traditional and contemporary textile designs of India and other countries like China, Japan etc. Application of art principles in textile designs such as constructed and surface / applied. Study of special fabrics like double cloth, damasks, brocades etc. Textiles design centres and their functions.

Unit 6 : Textile Industry in India

Textiles industry in India and its past and present status with reference to cotton, silk, wool, jute, rayon and synthetics. Garments and hosiery industries and their present status. Domestic and international consumption. Export and import policies of textiles and apparels. Sales promotion techniques for textiles and garments/apparels. Associations and research organizations related to textiles, garments, hosiery etc. and consumers. Textiles consumers' protection regulations. Need for consumer education in textiles and clothing.